

# Exhibit 06

IN THE UNITED STATES DISTRICT COURT  
FOR THE SOUTHERN DISTRICT OF NEW YORK

NIKE, INC.,  
Plaintiff,

vs.

STOCKX LLC,  
Defendant.

Case No. 22-cv-983 (VEC)

Expert Report of Scott Duke Kominers, Ph.D.  
May 5, 2023

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1. I am Scott Duke Kominers. I am a Professor of Business Administration in the Entrepreneurial Management Unit at Harvard Business School (HBS), and a Faculty Affiliate of the Harvard Department of Economics, as well as a Research Partner at a16z crypto, a venture fund investing in the crypto and web3 space that is part of the venture capital firm Andreessen Horowitz. I have research and teaching expertise in economics and market design, with a focus on marketplace business and, of late, a special focus on non-fungible tokens (NFTs) and other consumer crypto technologies. I also advise a number of marketplace businesses and crypto projects, including several NFT projects, and am an avid collector of NFTs and an active participant in a number of NFT communities. My Harvard address is Rock Center 219, Harvard Business School, Soldiers Field, Boston, Massachusetts, 02163.

## Assignment

2. I am being compensated for expert services in this matter at my customary hourly rate for expert work (\$1,500 per hour for consulting services, and \$2,000 per hour for testimony).
3. To complete this work, I worked with a research assistant, Tynan Seltzer, who is one of my former students. He was compensated at his customary rate for supporting expert research (\$500 per hour), and performed work entirely at my direction and under my supervision.
4. No part of my compensation or that of my research assistant is dependent upon the outcome of this action or the nature of the opinions that I express. Moreover, I do not hold—and have never held—NFTs from or associated with StockX. To my knowledge, I do not hold—and have never held—NFTs from or associated with Nike. Furthermore, the statuses of my NFT-related collaborations and advisory roles, mentioned above, are not dependent upon the outcome of this action or the nature of the opinions that I express.
5. For this matter, I was asked to explain what non-fungible tokens (NFTs) are, how they work, and the various ways in which they can be used. I was also asked to characterize the purpose, design, and features of the StockX Vault NFTs in that context, and to describe and contextualize those features in the context of best practices for NFT design and other NFT projects in the market.

## Summary of Opinions

6. NFTs are a technology that can be used in many different ways, including as a transferable digital record representing ownership of an associated physical product.
7. The StockX Vault NFTs represent an intuitive and economically valuable use of NFT technology, which has the potential to improve the overall efficiency of the collectibles resale market.
8. Design decisions StockX made when launching the Vault NFTs—specifically, (1) minting the Vault NFTs on Ethereum using the ERC-1155 token standard, (2) linking the NFT to an image depicting the physical product for which the NFT conveys ownership and is redeemable, and (3) managing trade in the Vault NFTs via an internal, off-chain transaction ledger—make sense from a market design perspective for an NFT that represents ownership in an underlying physical good held by a single third party, and are consistent with best practices for firms when first launching similar products.

9. The StockX Vault NFTs generally do not have features commonly associated with “digital brand” NFTs, which use digital assets as a springboard for establishing a broader product ecosystem and brand, along with a community of NFT holders who self-identify with the brand as such. But to the extent that the Vault NFTs do have any such features, the digital brand in question is unambiguously that of StockX alone.

## Qualifications

10. I hold an A.B. in Mathematics and an A.M. and Ph.D. in Business Economics from Harvard University. My research specialty is in market design, which uses economic theory and analysis to understand and inform the design and structure of real-world markets. In this context, I have studied marketplace business since 2011, worked on crypto-related market design applications since 2018, and focused particularly on questions of crypto token and incentive design since mid-2021.
11. I have written and published extensively on both the theory and practice of market design in refereed journals, as well as in edited volumes and series, practitioner journals, and opinion venues. I have written numerous academic case studies on market design topics, as well as extensive course and teaching notes on market design and marketplace entrepreneurship. I regularly give academic and public talks on these topics, both in the context of refereed/juried conferences, and in the context of invited talks and seminars. My academic papers and publications have received thousands of citations to date.
12. Especially over the last year and a half, my research has focused heavily on market design questions associated with crypto and the associated business, protocol, and platform models that have come to be called “web3.” I have published peer-reviewed market design framework articles with crypto applications, as well as an antitrust journal article on the role of crypto in shaping competition. I co-authored the first-ever *Harvard Business Review* article on NFTs,<sup>1</sup> as well as the first HBS case study on NFTs,<sup>2</sup> and the first HBS case study on an NFT marketplace,<sup>3,4</sup> and I have numerous other academic works on NFTs and crypto marketplace design in production. I also have written—at the explicit invitation of the editors—public-facing opinion articles and explainers on NFTs and crypto for venues such as *Bloomberg Opinion* and *Project Syndicate*. I am currently co-authoring a book on NFTs, *The Everything Token*, to be published by Penguin’s Portfolio imprint in early 2024. My crypto articles not only have been used as academic references, but also have influenced real-world crypto market design; for example, my co-authored articles in *Future* are frequently cited by crypto entrepreneurs as having informed their reputation token designs. A copy of my current CV is attached as Appendix 2 to this report.

<sup>1</sup>Steve Kaczynski and Scott Duke Kominers. “How NFTs Create Value”. In: *Harvard Business Review* (2022).

<sup>2</sup>Scott Duke Kominers, Das Narayandas, and Kerry Herman. *Bored Ape Yacht Club: Navigating the NFT World*. Harvard Business School Case 822-065. URL: <https://hbsp.harvard.edu/product/822065-PDF-ENG>.

<sup>3</sup>Scott Duke Kominers, Shai Bernstein, and George Gonzalez. *LooksRare: The Decentralized, Tokenized, NFT Marketplace*. Harvard Business School Case 822-119. 2022.

<sup>4</sup>These are the first HBS cases on these topics to my knowledge—a search for “NFT” in the internal, logged-in version of Harvard Business School Publishing platform turns up only two other cases on NFTs, both of which are subsequent to mine.

13. More broadly, and especially since I joined the HBS faculty in July, 2017, my research and teaching have focused on marketplace businesses and the role of new technologies in marketplace design. My course note on “Marketplace Design”<sup>5</sup> presents the framework and structure for a full course on designing, launching, and scaling marketplace businesses; my module note “Markets and Marketplaces: Core Concepts”<sup>6</sup> presents a shorter, survey-length series of course sessions covering the same material. The marketplace business framework notes I originally wrote for use in my class, “A Three-Part Framework for Entrepreneurial Marketplace Design”<sup>7</sup> and “Making Markets,”<sup>8</sup> have been used in various teaching contexts both at HBS and at other business schools, and have been cited by practitioners in their work. Similarly, my academic articles on marketplace frameworks and algorithms have appeared on course syllabi worldwide and have influenced the design of real-world marketplaces. At HBS, I teach an entrepreneurship course called “Making Markets” centered on marketplace business strategy and design. In this course, I have taught sessions framed around StockX and similar resale/exchange marketplaces, examining these platforms’ marketplace design strategies from the perspective of the platform creator, user, and/or investor. I also have covered crypto, web3, and NFT strategy, in my course, among other market design topics. As of January, 2023, I additionally co-teach a “Short Intensive Program” focused on crypto and web3 business, and I will be co-launching a new entrepreneurship course on “Building Web3 Businesses” in Spring, 2024. I also have taught in HBS’s general entrepreneurship sequence, “The Entrepreneurial Manager.” In addition, I am part of the founding team of Harvard’s Crypto, Fintech, and Web3 Lab, which is part of Harvard’s Digital, Data, and Design (D<sup>3</sup>) Institute; in this capacity, I am engaged in overall strategic planning around Web3 research and course development at the school.
14. I am frequently called upon to speak on NFTs specifically, and crypto and marketplace design more broadly, in lectures and conferences, as well as podcasts, Twitter “Spaces” (akin to live radio shows), and other forums. I taught three sessions at a16z crypto’s Spring, 2023 “Crypto Startup School,” presenting introductions to web3 business strategy, web3 intellectual property strategy, and auction theory.
15. I also both formally and informally advise numerous marketplace businesses and crypto projects on market design and business strategy. For example, I am a collaborator on the 1337 Skulls NFT project, an advisor to the Thingdoms and Hungry Wolves NFT projects, as well as Fine Digital, an NFT studio, and koodos, a “web3 Pinterest” centered around NFT creation and sharing. In the context of my work at a16z crypto, I advise a number of the firm’s portfolio companies on NFT strategy, tokenomics, and market design, more broadly. Drawing on my broader experience in market design, I also advise a number of marketplaces outside the crypto space, including Quora, Lunchclub, NCX, and OneChronos. And I provide regular *ad hoc* advice to students and entrepreneurs on their own marketplace and crypto ventures. These advising activities draw upon my extensive experience in market design, and my intensive research and

<sup>5</sup>Scott Duke Kominers. *Marketplace Design*. Harvard Business School Note 821-068. URL: <https://hbsp.harvard.edu/product/821068-PDF-ENG>.

<sup>6</sup>Scott Duke Kominers. *Markets and Marketplaces: Core Concepts*. Harvard Business School Note 821-069. URL: <https://hbsp.harvard.edu/product/821069-PDF-ENG>.

<sup>7</sup>Scott Duke Kominers. *A Three-Part Framework for Entrepreneurial Marketplace Design*. Harvard Business School Note 821-065. URL: <https://hbsp.harvard.edu/product/821065-PDF-ENG>.

<sup>8</sup>Thomas R. Eisenmann and Scott Duke Kominers. *Making Markets*. Harvard Business School Note 818-096. URL: <https://hbsp.harvard.edu/product/818096-PDF-ENG>.

engagement in the crypto space, specifically.

16. I was previously qualified to serve as an expert in *Hermès Int'l, et al. v. Rothschild*, No. 22 CV 398 (S.D.N.Y. 2022), in which I opined on behalf of Hermès regarding the NFT market, the position of various NFT projects within that market, and the ways in which NFTs obtain, and the basis for NFT, value. Other than *Hermès v. Rothschild*, I have not provided expert testimony during the past four years.
17. As I describe in more detail in the “Methodology” section below, my work requires me to regularly follow the NFT market, as well as the broader crypto market and technology trends. I am also heavily engaged in specific NFT communities, both in the context of my research and recreationally. I have collected hundreds of NFTs, most of which are held at the Ethereum addresses 0x34202f199ef058302dccc326a0105fe2db53e12 and 0xc0619bb479af57e9e76c1fb24bde919364291dca.
18. I continue to review materials and documents relevant to this case and reserve the right to supplement this expert report based on additional information that becomes available and/or any additional work I may be asked to do.

## Information Considered

19. A complete list of the materials I have considered is attached as Appendix 3 to this report.
20. The materials I have considered include information available on the StockX Website, Discord, and Twitter feed, and Etherscan, as well as related articles on the Web.
21. In addition, this report also draws on examples from the broader NFT market, including imagery and social media messaging associated with other NFT projects. These examples were mostly selected for illustration based on my own prior research and experience in the space. Some of the NFTs pictured or described as examples are part of NFT projects from which I personally have collected NFTs; this is disclosed in footnotes. And finally, the report draws upon my own articles and other articles in the literature on NFTs and crypto, as well as the economics and market design literature, more broadly.

## Methodology

22. Since at least 2011, I have been studying the design of marketplace businesses, and the various technologies, mechanisms, and strategies that marketplaces use to organize markets and enable transactions. In this context, for roughly the past 18 months, I have been studying the NFT market and associated market design applications of NFTs and other consumer crypto and blockchain technologies, especially in reference to how these technologies enable new types of markets, and how they stand to make existing markets more efficient. This work builds upon my prior research on crypto marketplace technologies focusing primarily on incentive design questions surrounding cryptocurrency protocols, as well as my broader research on general frameworks for market and marketplace design.

23. I conduct research on NFTs using both qualitative and quantitative methods, following a standard arc used when analyzing new market design contexts, technologies, and applications. My analysis involves analyzing real-world market conditions at both micro and macro levels, combining participant-observation and other ethnographic methods; reviewing primary and secondary sources; identifying and developing case studies; and establishing analogies and linkages to classic market design, mechanism design, platform competition, and game theory frameworks; as well as empirical analysis involving econometrics and other statistical frameworks. All of this work together feeds into development of novel theoretical frameworks and empirical economics research. My research on NFTs has involved interviews with NFT market participants, entrepreneurs, investors, and other stakeholders; it also draws upon my and my research collaborators' extensive engagement in the market and specific NFT communities.
24. Outputs of my research on NFTs include (1) a series of articles synthesizing the market in relation to established market frameworks, in venues such as *Harvard Business Review*, *CPI TechREG Chronicle*, *Future*, and *a16z crypto*<sup>9</sup>; (2) business case studies on NFTs and associated academic teaching materials; (3) both theory and empirical papers in development/preparation for submission to refereed journals; and (4) my practitioner-focused book in preparation, *The Everything Token*.
25. I used this same approach to study market design opportunities around vaccine production and cross-country vaccine allocation (2020–2022),<sup>10</sup> and market design responses to opportunistic patent litigation (2013–2019),<sup>11</sup> and that others have used in market design contexts ranging from the allocation of food to food banks,<sup>12</sup> to the design of wireless spectrum auctions.<sup>13</sup>
26. In this report, I draw upon my prior research on NFTs to provide background on the technology, market context, and market design aspects of NFTs, as well as the distinct business models that have emerged around NFTs. In addition, drawing on the various qualitative frameworks described above, I examine how the StockX Vault NFTs fit within the context of various NFT business models, and analyze the ways in which the design features of Vault NFTs serve their market design goals, including by comparing the Vault NFTs to other NFT projects, such as those released by Nike and its subsidiary RTFKT.

## What are NFTs?

27. NFTs are digital records of ownership.<sup>14,15</sup>

<sup>9</sup>The organization a16z crypto maintains a self-titled practitioner publication.

<sup>10</sup>Juan Camilo Castillo et al. “Market design to accelerate COVID-19 vaccine supply”. In: *Science* 371.6534 (2021), pp. 1107–1109; Eric Budish et al. “Distributing a billion vaccines: COVAX successes, challenges, and opportunities”. In: *Oxford Review of Economic Policy* 38.4 (2022), pp. 941–974.

<sup>11</sup>Lauren Cohen, Umit G. Gurun, and Scott Duke Kominers. “Patent Trolls: Evidence from Targeted Firms”. In: *Management Science* 65.12 (2019), pp. 5461–5486.

<sup>12</sup>Canice Prendergast. “How Food Banks Use Markets to Feed the Poor”. In: *Journal of Economic Perspectives* 31.4 (2017), pp. 145–162.

<sup>13</sup>Alexander Teytelboym et al. “Discovering auctions: Contributions of Paul Milgrom and Robert Wilson”. In: *Scandinavian Journal of Economics* 123.3 (2021), pp. 709–750.

<sup>14</sup>*Non-fungible tokens (NFT)*. URL: <https://ethereum.org/en/nft/>.

<sup>15</sup>Encyclopedia Britannica. “Non-fungible token”. In: (2023). URL: <https://www.britannica.com/topic/non-fungible-token>.

28. NFTs are typically recorded on a digital ledger called a blockchain.

- (a) *Blockchains* store data and conduct software processing across a distributed computer network. They use a cryptographically-secured process to make recorded data functionally immutable. Blockchain records are typically public, and their networks are often either partially or fully decentralized<sup>16,17</sup>.
- (b) Especially in decentralized blockchain contexts, users of a blockchain typically pay a processing fee, commonly referred to as a *gas fee*, for any updates to the ledger—including for creating or adjusting ledger records and for installing or updating software. These fees serve to compensate the computers (or rather, the owners of the computers) who maintain the ledger data, in a fashion loosely similar to the way in which users of a cloud computing solution might pay the service provider as a function of the amount of storage and computational time they use.<sup>18</sup>
- (c) Blockchains make it possible to create, store, and transfer a variety of digital assets including both *fungible tokens* and *non-fungible tokens*, described in more detail below.
- (d) Individual users control their digital assets on blockchains through an application called a *wallet*, which enables them to view and verify digital asset holdings, as well as (for transferable tokens) to securely transfer them to others, or exchange them for some form of consideration.<sup>19,20</sup>
- (e) Wallets for blockchain assets are managed through private cryptographic keys. Some wallets are “custodial,” in the sense that a third party manages those keys; others are “self-custodial,” in the sense that the user controls the private keys themselves.<sup>21</sup> In some contexts involving custodial wallets, a separate wallet is maintained for each user. In other contexts involving custodial wallets—especially in centralized crypto marketplaces and exchanges—wallets holding blockchain-based assets are maintained at the level of the platform, and an internal ledger is used to track individual user accounts.<sup>22</sup>

29. NFTs are non-fungible in the sense that each one is individually unique and identifiable, and this makes individual NFTs distinguishable in the market.

<sup>16</sup>McKinsey & Company. *What is blockchain?* Dec. 2022. URL: <https://www.mckinsey.com/featured-insights/mckinsey-explainers/what-is-blockchain>.

<sup>17</sup>Yiorgos Allayannis and Aaron Fernstrom. *An Introduction to Blockchain*. University of Virginia Darden School of Business Note 7356. URL: <https://hbsp.harvard.edu/product/UV7356-PDF-ENG>.

<sup>18</sup>*Gas and fees*. URL: <https://ethereum.org/en/developers/docs/gas/>.

<sup>19</sup>Coinbase. *Crypto basics – what is a crypto wallet?* URL: <https://www.coinbase.com/learn/crypto-basics/what-is-a-crypto-wallet>.

<sup>20</sup>Coryanne Hicks. “Understanding crypto wallets”. In: *Forbes* (Apr. 2023). URL: <https://www.forbes.com/advisor/investing/cryptocurrency/crypto-wallets>.

<sup>21</sup>Hicks, “Understanding crypto wallets”.

<sup>22</sup>For example, Coinbase explains: “For centuries, banks, asset managers, commodity brokers, and others in traditional finance have relied on something called an omnibus account to store funds. By combining many customer funds—and even house funds—in the same place, institutions can more easily move funds as withdrawals, deposits, and trades take place. And they keep track of which funds belong to which customer by using an internal ledger. Coinbase works the same way. When a transaction is executed, it’s immediately recorded on our ledger and it settles there, even before new blocks of information post on a blockchain. This makes everything fast and efficient—actions like crypto buying and selling, USDC minting, and moving to and from cold storage, which affords the highest level of cybersecurity protections” (Paul Grewal. *Coinbase’s blockchain-enabled approach to funds management and storage*. URL: <https://www.coinbase.com/blog/coinbases-blockchain-enabled-approach-to-funds-management-and-storage>).

- (a) Some NFTs are identifiably unique from every other NFT in existence—including ones with otherwise similar characteristics. This is similar to the way in which individual photographs produced by a given photographer are all distinct—and even repeated prints of a single photo might receive individual edition numbers.
  - (b) Other NFTs come in multiple units, in the same way that multiple units of a given baseball card might be printed, with all copies of that card considered equivalent, yet distinguishable from other cards, even of the same player.
  - (c) Non-fungibility separates NFTs from fungible assets, such as dollar bills or cryptocurrency, where all units are functionally equivalent.<sup>23</sup> In particular, a person is able to seek and acquire specific NFTs, so long as those NFTs are available in the market.
30. In the same way that physical deeds serve as ownership records for land or other physical property, NFTs serve as a form of “digital deed” representing ownership in digital or physical assets.
- (a) Depending on the context, those assets can be associated with the NFT in different ways.
  - (b) Sometimes, the association is embedded via explicit reference recorded in the software that defines the NFT.
  - (c) Other times, especially in the context of NFTs associated with physical goods or services, ownership is managed through contracts and/or terms of service (which may or may not themselves be stored on the blockchain).
  - (d) In still other contexts, the association is managed through third-party software, or simply agreed upon by social convention.
31. NFTs are created—or “minted”—by executing a software program to instantiate the tokens. At that time, and/or potentially later, the creator can define the assets and other property rights associated with the NFT. The creator typically has full control over the rules and functions of the software program that manages the NFT; once determined, however, these rules and functions often cannot be changed.
- (a) There are many different blockchains in active use that support NFT minting. Each of these blockchains is operated by its own network of computers, and many of these blockchains feature their own special technical or operational features that make them more or less appropriate for specific NFT applications. Many NFTs, for example, are created and hosted on Ethereum “mainnet,” which is the largest and most active base-layer blockchain with smart contract functionality.<sup>24</sup> Because the gas fees on Ethereum are quite high, NFTs associated with frequent-transaction applications like online games are often stored on NFT-optimized blockchains, such as Flow,<sup>25,26</sup> or “layer-two” blockchains, such

<sup>23</sup>As we discuss briefly below, a recent movement in the crypto market has started treating even certain formerly fungible cryptocurrency assets such as Bitcoin units as non-fungible, and even giving them embedded NFT characteristics. This is loosely analogous to the idea of adding drawings or other markings to a dollar bill in a way that makes it unique and distinctive relative to other bills.

<sup>24</sup>*Non-fungible tokens (NFT)*.

<sup>25</sup>Flow. *Flow Primer*. URL: <https://flow.com/primer>.

<sup>26</sup>PixelPlex. *Flow vs Ethereum. Which is best for NFT development?* URL: <https://pixelplex.io/blog/flow-vs-ethereum-comparison-best-platforms-for-nft/>.

as Polygon. Layer-two blockchains can be advantageous in that context because they batch transactions on the underlying mainnet for efficiency (and thus lower total gas fees).<sup>27</sup>

- (b) Similarly, there are different minting standards used to deploy NFTs. As an illustration, there are multiple NFT minting standards in active use on the Ethereum network. For example, the standard identified as “ERC-721” implements NFTs that are individually unique,<sup>28,29</sup> whereas the standard identified as “ERC-1155” implements NFT “editions,” with potentially multiple units of each NFT in the collection.<sup>30,31</sup> Unlike ERC-721 tokens, each of which must be minted and transferred individually, ERC-1155 editions of a particular NFT can be minted as a single batch and—if held by a single user—transferred in batches, as well. As mentioned above, Polygon is an Ethereum layer-two solution, and as such Polygon uses the same NFT standards as Ethereum mainnet. By contrast, the Flow blockchain (which is, for the most part, separate from Ethereum) has its own software language called Cadence which has its own non-fungible token standard.<sup>32</sup>
- (c) As the discussion above suggests, the choices between blockchains (or blockchain layers) and between NFT standards on those blockchains, depends on the NFT creator’s intended application or use for the NFT. ERC-721 is used, for example, for unique works and individually-numbered series. ERC-1155 is often used for “editions” or collectible series, akin to trading cards (see Figure 1, for example), where multiple units of each collectible are available. While it is in principle possible to implement open editions and series through the ERC-721 standard (and some creators do this), using the ERC-1155 standard makes it possible to save on gas fees by batch-minting multiple copies of a given token. The non-fungible token standard on the Flow blockchain, meanwhile, is especially optimized for NFTs that eventually need to be able to embed or “hold” other NFTs, as in the case of an NFT associated with a digital avatar “holding” NFTs associated with various metaverse wearables.<sup>33</sup>

<sup>27</sup>Cointelegraph. “Polygon Blockchain explained: A beginner’s guide to Matic”. In: *Cointelegraph* (July 2022). URL: <https://cointelegraph.com/learn/polygon-blockchain-explained-a-beginners-guide-to-matic>.

<sup>28</sup>ERC-721: *Non-Fungible Token Standard*. Jan. 2018. URL: <https://eips.ethereum.org/EIPS/eip-721>.

<sup>29</sup>ERC-721 *Non-Fungible Token Standard*. URL: <https://ethereum.org/en/developers/docs/standards/tokens/erc-721/>.

<sup>30</sup>ERC-1155: *Multi-Token Standard*. June 2018. URL: <https://eips.ethereum.org/EIPS/eip-1155>.

<sup>31</sup>ERC-1155 *Multi-Token Standard*. URL: <https://ethereum.org/en/developers/docs/standards/tokens/erc-1155/>.

<sup>32</sup>Onflow. *Onflow/flow-NFT: The non-fungible token standard on the Flow blockchain*. URL: <https://github.com/onflow/flow-nft>.

<sup>33</sup>Flow. *Composable resources*. URL: <https://developers.flow.com/cadence/tutorial/10-resources-compose>.

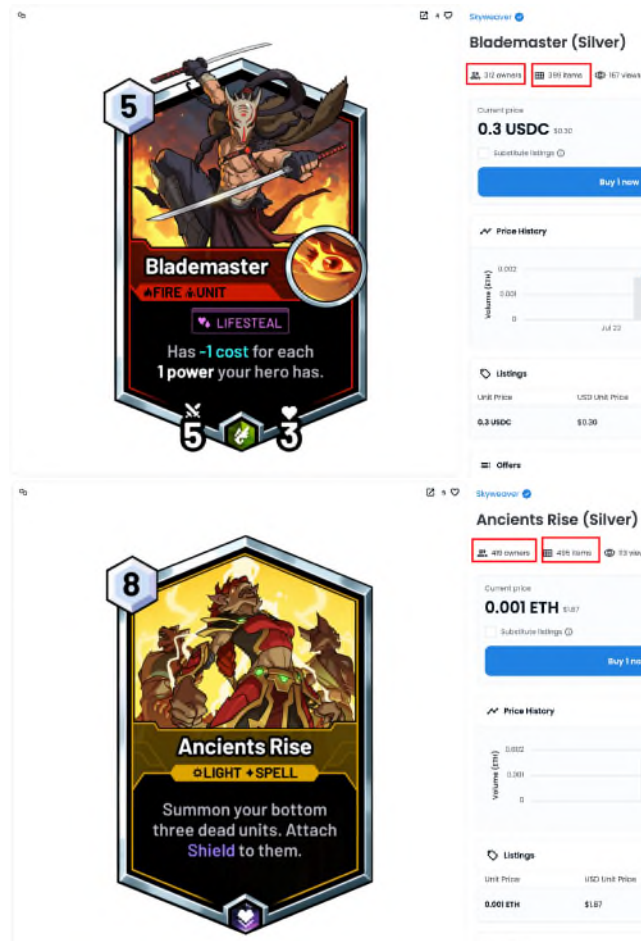


Figure 1: ERC-1155 NFTs representing two cards from the Skyweaver card game.<sup>35</sup> As highlighted in red, there are 399 editions of the Blademaster NFT, and 495 editions of the Ancients Rise NFT.

- (d) Because different blockchains and standards have different strengths, a given creator might use several of the different token implementations just described, depending on the intended purpose of the NFTs. For example:
- i. The NFT creator known by the online username “ripcache” has created both one-of-one (“1/1”) and numbered series (e.g., branch 1, branch 2, ...) NFTs using the ERC-721 standard, and has also created unnumbered editions (where there are a limited number of tokens that are not each associated with discrete edition numbers) using the ERC-1155 standard.<sup>36</sup> As displayed in the NFT marketplace platform OpenSea, each ERC-721 token (which has a discrete edition number) shows a single owner (Figures 2 and 3); the ERC-1155 tokens, which do not have discrete edition numbers, show a set of owners, with multiple units, and also give a prospective buyer the option of purchasing multiple units at once (Figure 4).

<sup>35</sup>Horizon Games. *Skyweaver - Collection*. URL: <https://opensea.io/collection/skyweaver>

<sup>36</sup>*Disclosure: I hold a ripcache NFT.*

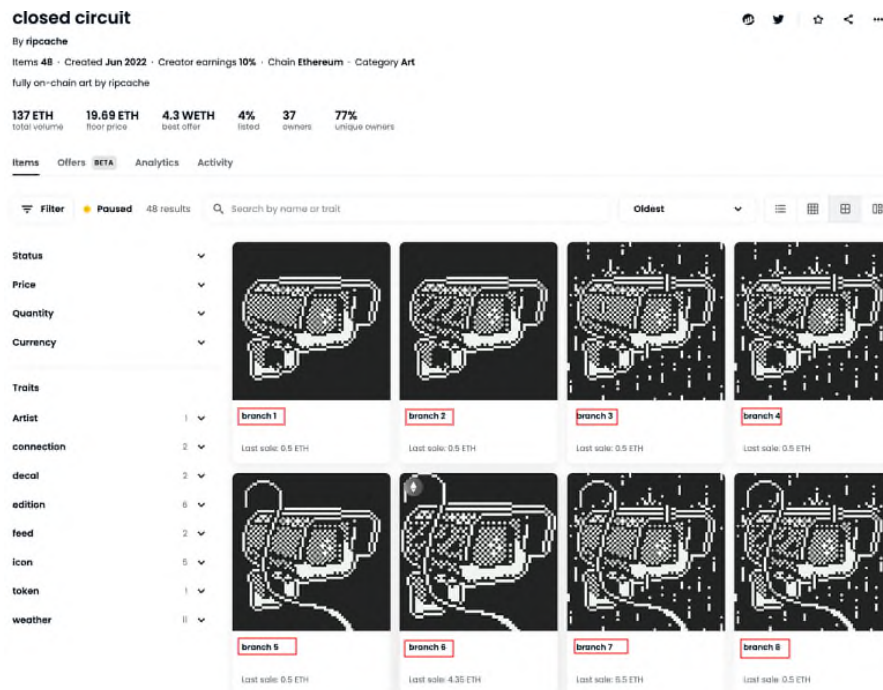


Figure 2: “closed circuit” collection by ripcache,<sup>38</sup> a numbered series of NFTs implemented under the ERC-721 standard.

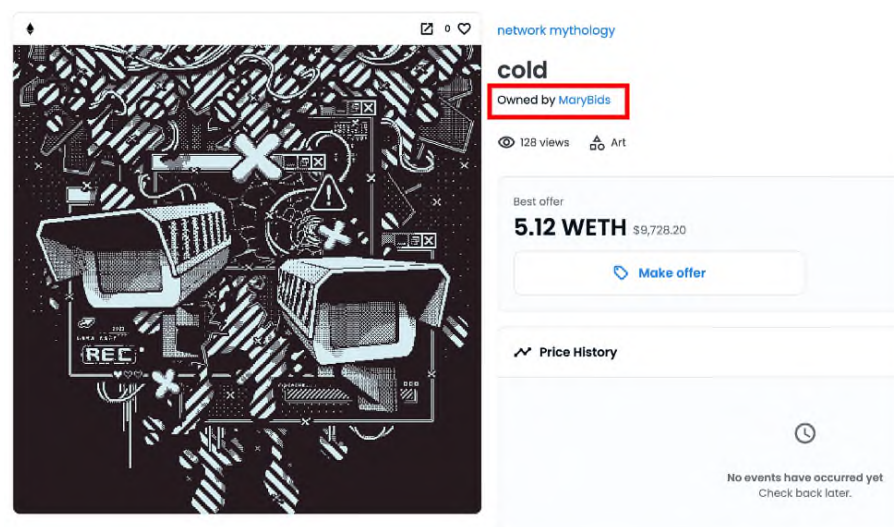


Figure 3: “cold” by ripcache,<sup>39</sup> a 1/1 NFT implemented under the ERC-721 standard.

<sup>38</sup>ripcache. *closed circuit* - Collection. URL: <https://opensea.io/collection/closed-circuit>

<sup>39</sup>ripcache. *Cold* - network mythology. URL: <https://opensea.io/assets/ethereum/0x7729a0f914e5a0d3e9c771f018f49fd1d278d1a/15>

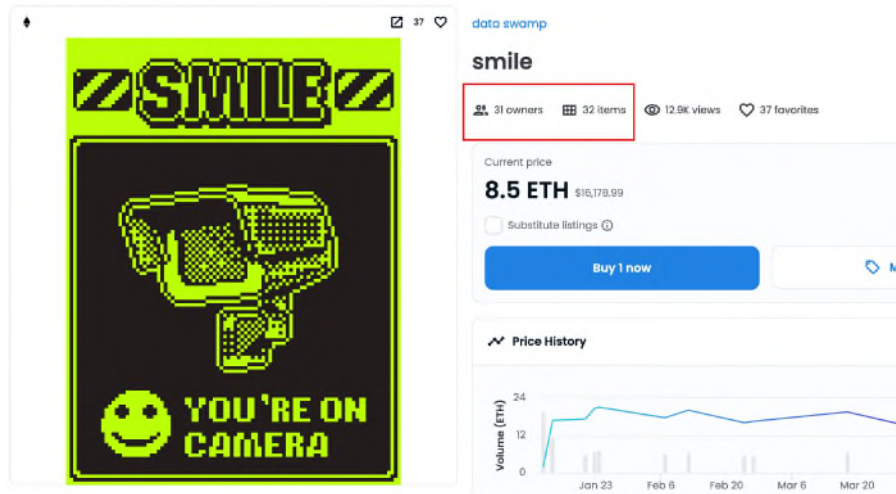


Figure 4: “smile” by ripcache,<sup>40</sup> an NFT with 32 copies implemented under the ERC-1155 standard.

- ii. The Doodles NFT project issued its original tokens, a series of individually unique cartoon “PFP” images in pastel colors, using the ERC-721 standard.<sup>41</sup> Doodles has announced that its new collection, which will feature collectible and swappable wearables (i.e., digital clothing that can be worn by online avatars), will be implemented on the Flow blockchain, taking advantage of that blockchain’s special efficiency for attaching NFTs to other NFTs.<sup>42</sup> (See Figure 5.)

<sup>40</sup>ripcache. *smile - data swamp*. URL: <https://opensea.io/assets/ethereum/0x34bc1299fb22219a4537fc41c5dd9a9efd2c976c/2>

<sup>41</sup>“PFP” stands for “Picture For Proof,” as well as (more colloquially) “ProFile Picture,” and has become a standard category of NFT series in which each NFT is linked to a unique digital image that is intended to be used as a profile picture/digital avatar on social media platforms.

<sup>42</sup>Flow. *Announcing Doodles 2 is coming to Flow*. URL: <https://flow.com/post/flow-blockchain-doodles-2-announcement>.

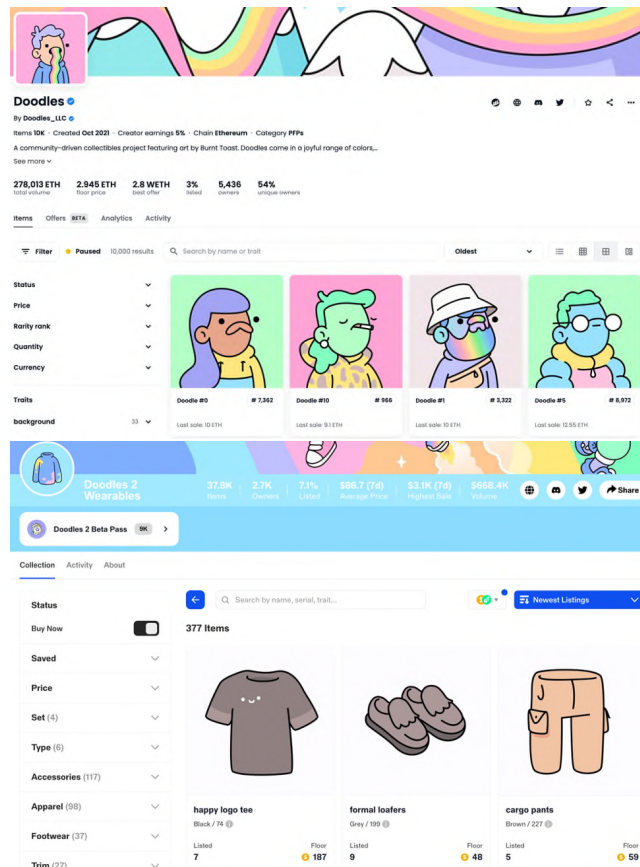


Figure 5: Top: The Doodles PFP collection, implemented via the ERC-721 standard. Bottom: The Doodles Wearables collection on Flow, with multiple copies of each wearable.<sup>44</sup>

- iii. RTFKT and Nike have used the ERC-721 standard for their PFP and CryptoKicks collections. They also have used the ERC-721 standard for a series of individually numbered digital posters,<sup>45</sup> corresponding to the way in which physical posters or prints might be individually numbered.
- iv. By contrast, the ERC-1155 standard is used for many metaverse wearables where multiple copies of the same item are available (just as with physical clothing items, even limited-edition digital wearables are typically issued with multiple units of each item available). For example, Dolce & Gabbana issued their series of “Disco Drip” wearables NFTs using the ERC-1155 standard. These “Disco Drip” wearables are virtual items users can wear in certain metaverse platforms (Figure 6).<sup>46</sup>

<sup>44</sup>Doodles. *Doodles 2 Wearables: Gaia - NFT Marketplace on Flow*. URL: <https://ongaia.com/doodles2wearables>; Doodles. *Doodles - Collection*. URL: <https://opensea.io/collection/doodles-official>

<sup>45</sup>Nike. *Nike: Our Force 1 - Poster - Collection*. URL: <https://opensea.io/collection/nike-our-force-1-poster>.

<sup>46</sup>Disclosure: As illustrated in the figure, I hold a Dolce & Gabbana “Disco Drip” NFT.



Figure 6: My avatar in Decentraland wearing a Dolce & Gabbana “Disco Drip” wearable associated with an NFT I own.

- v. The ERC-1155 standard is similarly used to mint other types of series of collectible items or trading cards, including NFTs that are connected to physical goods. For example, RTFKT and Nike used the ERC-1155 standard for their “RTFKT Clone X Forging SZN 1 (PRE-FORGE)” NFTs. These NFTs could be redeemed for physical goods, which were depicted on an image linked to the NFT,<sup>47</sup> through a process known as “forging.” In the forging process (depicted in Figure 7), an owner of one of these ERC-1155 NFTs connects their wallet to the RTFKT website, and redeems their ERC-1155 NFT by “burning” it; they are then shipped the physical good and additionally receive an ERC-721 NFT corresponding to the shipped physical good. The physical good typically bears a Near Field Communication (NFC) tag, which allows a user to link their corresponding ERC-721 NFT to the physical product.<sup>48,49</sup>

<sup>46</sup>ripocache, *smile - data swamp*

<sup>47</sup>RTFKT. *RTFKT Clone X forging SZN 1 (PRE-FORGE) - Collection*. URL: <https://opensea.io/collection/clonexforging>.

<sup>48</sup>RTFKT Discord post in the #announcements channel, 22 July 2022, 1:51 PM ET.

<sup>49</sup>Note that this also provides an illustration of the difference between ERC-721 and ERC-1155 standards in application: the ERC-1155 token represents an edition of multiple identical units, which is replaced with an ERC-721 token uniquely linked to a single specific unit of the physical product after the redemption (“forging”) process occurs.

## Nike RTFKT Forging

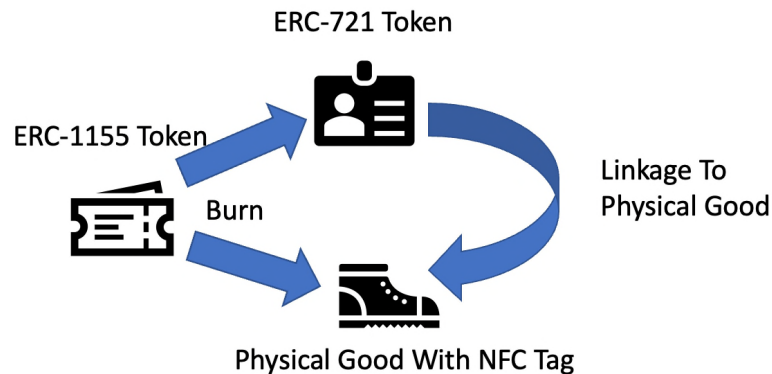


Figure 7: A visualization of the Nike RTFKT forging process. An ERC-1155 NFT is burned in exchange for a physical good being shipped to the holder and an ERC-721 NFT, which can be linked to the physical good via the NFC tag in the physical good.

- (e) Irrespective of which minting process is used, the number of NFTs in a given collection is often limited so as to create a form of scarcity. Many NFT collections, including those of ripcache, Doodles, and RTFKT, described above, and Yuga Labs, described below, have relied in part on scarcity as a driver of value. For NFTs linked to digital goods, this scarcity is imposed by the NFT itself, as digital goods are theoretically infinitely reproducible, subject only to storage limitations. For NFTs linked to physical goods, the scarcity of the NFT is imposed as a function of the scarcity of the underlying linked physical assets available to the NFT creator.<sup>50</sup>
- (f) The level of scarcity of an NFT is often calibrated relative to initial or projected market demand. For example, the company Yuga Labs has released a series of NFT collections with the number of NFTs per-collection generally increasing over time as demand to enter the Yuga Labs product ecosystem has expanded. Yuga Labs's original Bored Ape Yacht Club NFT collection had 10,000 tokens. Later, the Mutant Ape Yacht Club NFT series was created with a maximum collection size of 20,000 tokens, giving each existing Bored Ape Yacht Club NFT holder access to a Mutant Ape NFT, and then selling 10,000 additional Mutant Ape NFTs in the public market. More recently, Yuga Labs's Otherside Otherdeeds project launched with a collection size of approximately 60,000 tokens, again expanding supply based on increased market demand for Yuga NFT assets.<sup>51</sup>
- (g) In addition to the on-chain components of an NFT—which include the software that manages NFT minting, transfer, and other operations, as well as any on-chain metadata—NFT creators often introduce terms of service/use at or before the time of minting. As already described, such terms are typically specified in ordinary contracts (although references

<sup>50</sup>Note that not all NFT collections entail fixed supply or even relative scarcity—for example, in many blockchain-based games, in-game items are represented as NFTs that are created and/or destroyed through gameplay, and total supply may grow arbitrarily large as people play the game.

<sup>51</sup>Disclosure: I hold both NFTs and fungible tokens from Yuga Labs.

to those contracts are sometimes incorporated into the software that manages the NFT). Unlike the core definitional and software elements of an NFT (which often cannot be changed), the associated terms of use/service are often subject to change, just as they are in most software services and web platforms. For example, the company MegaVolt Corp grants holders of its SupDucks NFTs various rights to produce derivatives of the imagery associated with their NFTs (discussed further below), and has changed the specific language and terms several times since inception.<sup>52,53</sup>

32. Many NFTs are transferable, and often this is part of their value and utility. Creators and other holders of transferable NFTs can keep them, gift them to others, or sell them, all through almost instantaneous digital transactions. Following an NFT transfer or sale, the ownership rights associated with the NFT transfer to the new owner.
  - (a) Blockchain-based NFTs can be transferred by accessing the software underlying the NFT directly. In this case, the transfer of token ownership is recorded on the blockchain.
  - (b) There are also a number of platforms that support public blockchain-based NFT listing/purchasing and/or swapping. These platforms provide software that enables prospective traders to set terms (such as bids and asks) and then securely exchange their digital assets on the blockchain using the underlying software governing the NFT. (Again, in this case, the transfer of token ownership is recorded on the blockchain.) Examples of NFT marketplace platforms that operate on the Ethereum network include OpenSea, LookRare, and SudoSwap.
  - (c) NFTs are also sometimes exchanged on partially or fully centralized ledgers. In such cases, transactions may or may not eventually be settled on the blockchain. This is akin to the way centralized cryptocurrency exchanges such as Coinbase work: they maintain their own ledger of trades among their users, periodically settling on-chain as necessary.<sup>54</sup> Similarly, PayPal introduced a fully custodial crypto wallet, where users can send cryptocurrency to and from their Paypal accounts, but the crypto wallets associated with the service are owned and managed by Paypal.<sup>55,56</sup> Using a centralized ledger alleviates some of the transaction fees (i.e., the gas fees) associated with blockchain settlement. Moreover, it serves to simplify the user experience, and in particular can avoid users having to manage their own crypto security. For example, many people who trade crypto assets on centralized exchanges do not have their own crypto wallets. Another recent example of a type of token for which a (partially) centralized ledger was maintained is that of “Ordinal” NFTs, a category of NFT created by adding imagery or other metadata to individual units

<sup>52</sup>MegaVolt Corp. *SupDucks NFT Ownership IP Rights*. URL: <https://megavolt.notion.site/SupDucks-NFT-Ownership-IP-Rights-09dc4f0ab82646d7a56c7b49b05fe9ad>.

<sup>53</sup>*Disclosure: I hold SupDucks NFTs and other NFTs from their digital brand ecosystem*.

<sup>54</sup>Coinbase. *Why can't I see my transaction on the blockchain?* URL: <https://help.coinbase.com/en/coinbase/trading-and-funding/buying-selling-or-converting-crypto/why-cant-i-see-my-transaction-on-the-blockchain>.

<sup>55</sup>PayPal. “PayPal launches new service enabling users to buy, hold and sell cryptocurrency”. In: *PayPal Newsroom* (Oct. 2020). URL: <https://newsroom.paypal-corp.com/2020-10-21-PayPal-Launches-New-Service-Enabling-Users-to-Buy-Hold-and-Sell-Cryptocurrency>.

<sup>56</sup>Tomio Geron. “PayPal is making its crypto wallet more useful”. In: *Protocol* (June 2022). URL: <https://www.protocol.com/bulletins/paypal-crypto-wallet>.

of the Bitcoin cryptocurrency called satoshis.<sup>57</sup> Many early buyers and sellers of Ordinal NFTs lacked the technical sophistication to manage the on-chain trading process for such NFTs, so the assets were often held centrally, and ownership was tracked on public spreadsheets such as the one shown in Figure 8.<sup>58</sup>

Username	BIDS			ASKS			
	BTC	ETH	USD	USD	ETH	BTC	Punk and Username
moske	2.2	33.80	\$62,700	\$55,575	29.96	1.95	Punk 19 / (Magic Eden)
moske	2.2	33.80	\$62,700	\$57,000	30.73	2	Punk 64 / (Magic Eden) *stolen*
pool	2.2	33.80	\$62,700	\$78,375	42.25	2.75	Punk 66 / ZimmerAllDay#1297 (Magic Eden)
mistor [WTB SUB 600]	2.2	33.80	\$62,700	\$81,225	43.79	2.85	Punk 65 / dangerz0ne#8784 (Magic Eden)
JoJo22 (+ 0.5 in ordinals)	2	30.73	\$57,000	\$84,075	45.32	2.95	Punk 61 / Grug#0675 (6 BTC on Magic Eden)
Oxdaddy	2	30.73	\$57,000	\$84,075	45.32	2.95	Punk 51 / (Magic Eden)
nex7	2	30.73	\$57,000	\$105,165	56.69	3.69	Punk 85 / tropoFarmer#0001 (Magic Eden)
Milky wise	2	30.73	\$57,000	\$114,000	61.46	4	Punk 38 / ManaNoob#2100
DHUSTLE	2	30.73	\$57,000	\$114,000	61.46	4	Punk 78 / anon999.eth#8768 (Magic Eden)
eyeshield . VKu	2	30.73	\$57,000	\$116,850	62.99	4.1	Punk 72 / 888#6483
gundown 7	2	30.73	\$57,000	\$128,250	69.14	4.5	Punk 96 / nola#6670
Ericuuuh	1.8	27.65	\$51,300	\$145,350	78.36	5.1	Punk 90 / Uncle B#1834
Apeman	1.7	26.12	\$48,450	\$145,635	78.51	5.11	Punk 95 / mrmorgo#5545
buggy	1.6	24.58	\$45,600	\$156,750	84.50	5.5	Punk 100 / StephKongCurry
crustilama	1.5	23.05	\$42,750	\$171,000	92.18	6	Punk 64 / jayefunk#2417
Buski	1.5	23.05	\$42,750	\$182,400	98.33	6.4	Punk 93 / matman_xyz#3430 (Magic Eden)
dizzle	1.5	23.05	\$42,750	\$196,650	106.01	6.9	Punk 32 / brennen.eth#7360 (Magic Eden)
joinjonjon	1.05	16.13	\$29,925	\$199,500	107.55	7	Punk 33 / (Simo)777#4176
pampalino.btc	1.021	15.69	\$29,099	\$199,500	107.55	7	Punk 16 / CrownJewel#0369
monet	1	15.36	\$28,500	\$228,000	122.91	8	Punk 100 / StephKong Curry#7751
p4rma	1	15.36	\$28,500	\$242,250	130.59	8.5	Punk 45 / tnols#1970
Light.Eth	1	15.36	\$28,500	\$262,770	141.65	9.22	Punk 22 / mksala#0144
rubberjesus	1	15.36	\$28,500	\$285,000	153.64	10	Punk 29 / 018.eth#1041

Figure 8: An image of a public spreadsheet used to track the bids and asks for Ordinal Punk NFTs.<sup>59</sup>

## NFT Use Cases

33. Because NFT technology can theoretically be used to record ownership of many different types of assets in the physical or digital worlds, there are a wide variety of actual and potential use cases for NFT technology.
34. Some NFTs serve purely as a digital ownership record.
  - (a) This is a variation of the way in which we use deeds or other record systems to document and transfer ownership of certain physical or digital assets that are difficult to physically transfer, such as real estate, gold bullion, or—in a very different sense—a digital image.
  - (b) These ownership-only NFT use cases are valuable from the perspective of market design because they significantly reduce the friction inherent in defining and verifying ownership, and enabling trade.
  - (c) There are many different ownership-only NFT product categories—defined by the various types of digital or physical goods associated with the NFTs.

<sup>57</sup>Disclosure: I hold Ordinal NFTs.

<sup>58</sup>Paul Ugbede Godwin. *Rodarmor 'Ordinals' Bitcoin NFTs spark trading volumes on the Bitcoin Network*. Feb. 2023. URL: <https://www.tekedia.com/rodarmor-ordinals-bitcoin-nfts-spark-trading-volumes-on-the-bitcoin-network/>.

<sup>59</sup>Ordinal Punks. *Ordinal Punk's data*. URL: [https://docs.google.com/spreadsheets/d/1\\_a690MxZUFGMnvU8VvkchH1wLUxUQKdTbJpF9geBpHqI/edit#gid=0](https://docs.google.com/spreadsheets/d/1_a690MxZUFGMnvU8VvkchH1wLUxUQKdTbJpF9geBpHqI/edit#gid=0)

- (d) Examples of ownership-only NFT categories for digital goods include those for “art” (imagery or other media, often interpreted as digital collectibles), web domains (such as digital address records issued by the Ethereum Name Service), music files, and e-books. Ownership-only NFTs are also sometimes used for account IDs—for example, Nike issues “.swoosh” NFTs that are used to uniquely identify users in its digital asset ecosystem.<sup>60,61</sup>
- (e) There is a growing category of NFTs predominantly or entirely functioning as ownership records for physical goods or services. These NFTs can typically be “redeemed” for the physical asset through a process in which the physical asset holder then is contractually obligated to deliver the physical asset to the NFT’s owner in exchange for the NFT owner modifying, surrendering, or deleting the NFT. One particularly well-known example is the “Tungsten Cube,” where a metal supplier created a one-ton tungsten cube, and an associated NFT, which they sold for \$250,000. Whoever owns this NFT has the right to visit the cube once per year and can at any point burn the NFT to have the cube shipped to them.<sup>62</sup> As another, more commonplace example, NFTs are now being used for live event tickets; holding such an NFT entitles the person to access the event venue and attend the event, just like with a physical ticket. The VeeCon conference, for example, issued tickets as NFTs, and entry into its real-world convention was conditioned on showing proof of ownership of the NFT.<sup>63</sup> There are numerous instances of NFTs effectively serving as claim checks for physical merchandise, with the physical good typically depicted (sometimes in stylized form) on an image associated with the NFT: Azuki,<sup>64,65</sup> Gutter Cat Gang,<sup>66,67</sup> and RTFKT/Nike,<sup>68</sup> for example, have issued NFTs that can be redeemed for exclusive merchandise that is depicted on associated imagery linked to the NFT (see Figure 9). Similarly, services such as BlockBar and BAXUS (currently in private beta) issue NFTs associated with products—in this case, high-end alcohol. As BlockBar’s website explains, its NFTs allow manufacturers to send bottles of liquor or wine to be held in centralized, secure storage.<sup>69</sup> The platform sells NFTs for each bottle, which can be traded among prospective holders while the bottles remain in storage. The holder of a given NFT can redeem it for the associated bottle at any time.<sup>70</sup> BAXUS works similarly, except instead of manufacturers sending alcohol, private owners send the alcohol and receive the NFT for each bottle in return (Figure 10).<sup>71</sup>

<sup>60</sup>Nike. *.SWOOSH Website*. URL: <https://www.swoosh.nike/>.

<sup>61</sup>Nike. *Swoosh ID - Collection*. URL: <https://opensea.io/collection/swoosh-id>.

<sup>62</sup>James Vincent. “A one-ton tungsten cube was just bought by a crypto cabal for \$250,000”. In: *The Verge* (Nov. 2021). URL: <https://www.theverge.com/2021/11/3/22761305/tungsten-cube-meme-nft-crypto-midwest>.

<sup>63</sup>VeeCon. *FAQ: VeeCon 2023*. Apr. 2023. URL: <https://veecon.co/terms-of-use/>.

<sup>64</sup>Chiru Labs. *Twin Tigers Jacket - Collection*. URL: <https://opensea.io/collection/twintigersjacket>.

<sup>65</sup>*Disclosure: I hold NFTs from the Azuki digital brand ecosystem.*

<sup>66</sup>Gutter Labs. *Gutter Merch Collection 1.0*. URL: <https://opensea.io/assets/ethereum/0x2163f70d3b4de18a44e570309798elfbb916291/101212>.

<sup>67</sup>*Disclosure: I hold NFTs from the Gutter Cat Gang digital brand ecosystem.*

<sup>68</sup>RTFKT, *RTFKT Clone X forging SZN 1 (PRE-FORGE) - Collection*.

<sup>69</sup>BlockBar. *Blockbar.com: How it Works*. URL: <https://blockbar.com/how-it-works>.

<sup>70</sup>BlockBar, *Blockbar.com: How it Works*.

<sup>71</sup>BAXUS. *BAXUS Website*. URL: <https://baxus.co/>.

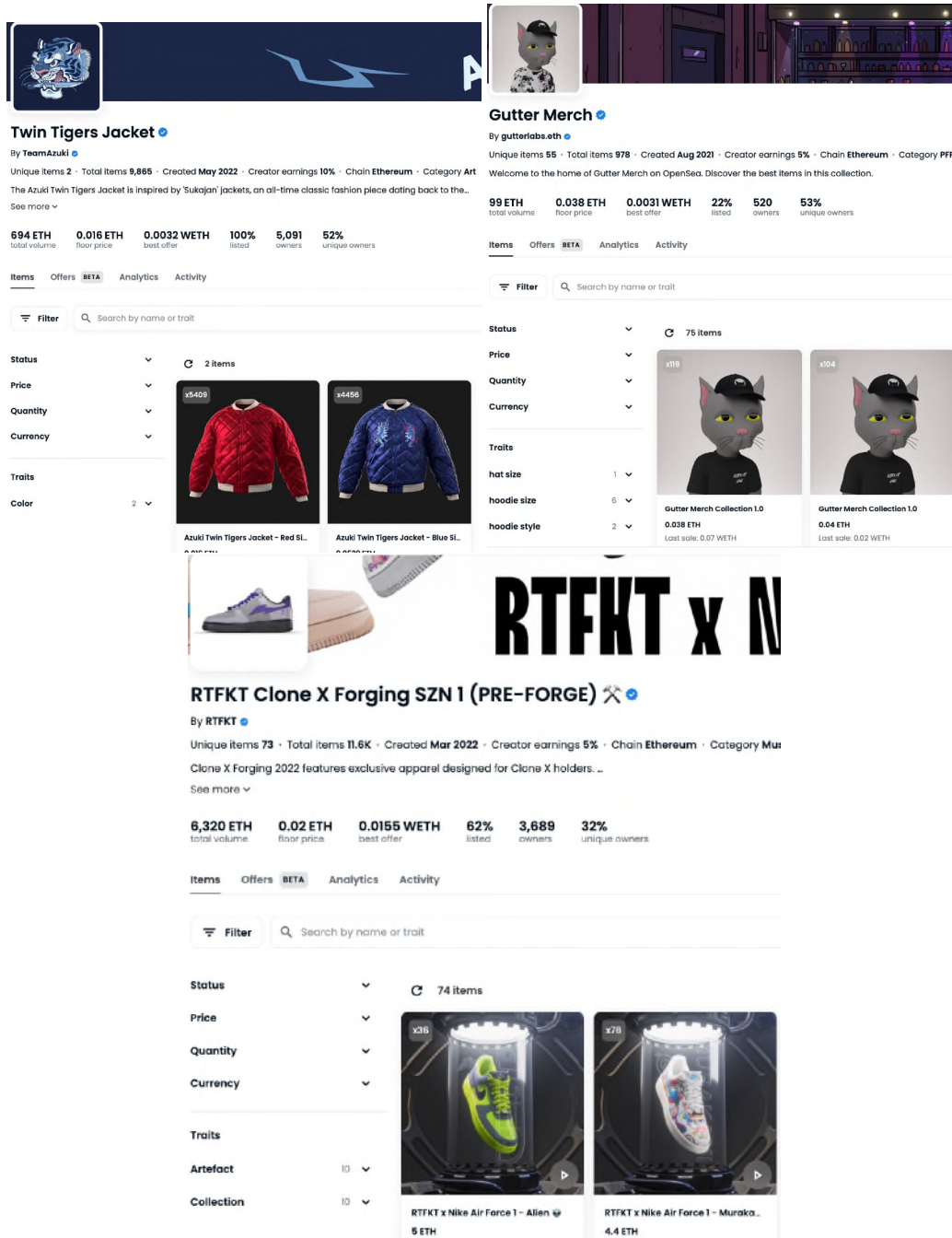


Figure 9: Example NFTs that have been associated with redeemable merchandise from Azuki (top left), Gutter Cat Gang (top right), and Nike/RTFKT (bottom).



Figure 10: An image taken from BAXUS's website explaining their process.

- (f) While the uses discussed thus far are primarily in the context of tradable NFTs (for example, using NFTs to enable trade in the ownership of a given domain name or bottle of whiskey), there are also a number of product categories built around non-transferable NFTs. These NFTs are issued to a specific crypto wallet and while they are sometimes configured so that they can be destroyed or replaced by the original issuer, they cannot be transferred through any form of sale or exchange. Such NFTs can, for example, be used for digital certifications—the Massachusetts Institute of Technology has issued “digital diplomas” as NFTs since 2017,<sup>72</sup> and more recently some firms have begun issuing NFTs of work histories or other similar credential information such as continued professional education (some of which are dynamic and can change as new credentials are acquired).<sup>73</sup> A different category of non-transferable NFT comprises digital badges commemorating

<sup>72</sup>Elizabeth Durant and Alison Trachy. “Digital Diploma debuts at MIT”. in: *MIT News* (). URL: <https://news.mit.edu/2017/mit-debuts-secure-digital-diploma-using-bitcoin-blockchain-technology-1017>.

<sup>73</sup>MyLearningNFT. *Why a Dynamic NFT?*. URL: <https://mylearningnft.com/why-a-dynamic-nft/>.

specific activities or events, often through an NFT standard called the Proof of Attendance Protocol (POAP).

35. NFTs can be given additional functionalities over and above simple ownership, referred to in the NFT market as *utility*. Utility can be provided by an NFT’s creator or by third parties, and often leverages the fact that NFTs are themselves embedded in software.

(a) Example utility formats include:

- *Access*: NFTs often grant various forms of exclusive access through “token-gating,” i.e., configuring software or other processes to allow access only to those users who can demonstrate that they hold the relevant NFTs in their wallets. For example, NFTs might grant holders admission to private chat channels where they can engage with each other, private websites with special merchandise access, or exclusive events. As a famous example, Yuga Labs throws an annual celebration and music festival known as ApeFest, which is only accessible to Bored Ape Yacht Club members, Mutant Ape Yacht Club members, and their guests.<sup>74</sup>
- *Airdrops*: It is possible to give additional assets to NFT holders—including additional NFTs—through a form of direct delivery called an “airdrop,” which is loosely analogous to email, in the sense that the new assets are sent directly to NFT holders’ wallets.<sup>75,76</sup>
- *Functional use*: Some NFTs (and their associated assets) have a form of direct use in various platforms or online games. For example, many blockchain-based games have in-game items that are encoded via NFTs; the holder of such an NFT can use the item in the game world, and potentially execute actions that modify or “use up” the NFT itself. Similarly, an NFT associated with a digital fashion item might grant the holder the right to “wear” the associated item in a metaverse platform such as The Sandbox or Decentraland (again, see Figure 6).
- *Licensing*: NFTs sometimes grant holders the right to use intellectual property embedded in associated media or other assets. For example, holders of NFTs from the SupDucks collection receive ownership of an associated duck image, and are granted a license to create both personal and commercial derivatives of that image, as shown in Figure 11.

<sup>74</sup>Yuga Labs. *ApeFest 2022 in NYC*. URL: <https://apefest.com/>.

<sup>75</sup>Andrey Sergeenkov. “What Is a Crypto Airdrop?” In: *CoinDesk* (n.d.). URL: <https://www.coindesk.com/learn/what-is-a-crypto-airdrop/>.

<sup>76</sup>Langston Thomas. “A pillar of the BAYC universe: Meet the Mutant Ape Yacht Club”. In: *nft now* (Oct. 2022). URL: <https://nftnow.com/guides/a-pillar-of-the-bayc-universe-meet-the-mutant-ape-yacht-club/>.

**2. License:**

MegaVolt Corp grants you a worldwide, assignable, sub-licensable, transferable, royalty-free license to reproduce, prepare derivative works of, publicly perform, display, modify, or otherwise use, copy, display, and modify your owned SupDucks NFT art.

For clarity, this includes the right to:

- Buy, sell, trade, and transfer your NFT
- Use the art to promote your products featuring your owned SupDucks NFT
- Create derivative works based on your owned SupDucks NFT (including by integrating the art and trait assets associated with the NFT)
- Sublicense to others to create derivative works featuring the art
- Produce and sell digital media and print merchandise that includes the art
- Use the SupDucks name, icon, and logo in connection with your SupDucks NFT

Figure 11: An excerpt from the SupDucks holder intellectual property license.<sup>77</sup>

- **Rewards:** NFT creators sometimes deliver various forms of rewards to holders—for example, in the form of discounts or premium buyer status. Sometimes these rewards are granted to all holders from a given NFT collection or series; other times, they apply to holders of specific NFTs within a collection, or to “top” holders (i.e., those who have a particularly large number of NFTs from the collection). For example, Starbucks maintains an NFT-based reward program called Starbucks Odyssey; holders of multiple Starbucks “Journey Stamp” NFTs recently received preferential access to the new “First Store” NFT collection.<sup>78,79</sup>
- (b) Many NFTs have what I call a “default utility,” which is a core function of the NFT defined from inception. Examples include:
- display of the associated media assets, in the case of an NFT for ownership of digital media;
  - utilization of a domain address, in the case of an NFT for ownership of a web domain;
  - playing a song or album, in the case of an NFT for ownership of digital music files;
  - redemption, in the case of an NFT for a physical good or service (e.g., attending an event using an NFT ticket, or obtaining a linked physical good by redeeming the NFT).
- (c) Other utility can be “additive,” in the sense that it builds new functionality on top of the baseline asset—a given NFT can have multiple utilities at once. For example, a digital ticket NFT might have access to a given concert as its default utility; and then a week after the concert, the artist might airdrop a digital collectible (perhaps an NFT associated with a music clip from the concert) to ticket NFT holders.
- (d) Note that utility functionalities that are the default for some NFTs can be additive for others. For example, Bored Ape Yacht Club NFTs grant ownership of a particular Ape image, but the parent company Yuga Labs also has added various access functionalities

<sup>77</sup>MegaVolt Corp, *SupDucks NFT Ownership IP Rights*

<sup>78</sup>Starbucks. *Starbucks Odyssey: The First Store Collection*. URL: <https://www.niftygateway.com/collections/starbucks-odyssey-the-first-store>.

<sup>79</sup>Disclosure: I am a member of the Starbucks Odyssey rewards program, and hold associated NFTs.

to the tokens, including access to exclusive chat rooms, merchandise, and events; these functionalities represent additive utility for the Bored Ape Yacht Club NFTs. By contrast, for a digital ticket NFT, access to the associated event would be the default utility.

36. *Digital brand* NFTs leverage utility to drive holders to integrate the tokens or associated assets into their personal identities both online and offline, and to coalesce into a “community of holders” closely connected to the NFT brand.
- (a) In our in-progress book, Steve Kaczynski and I talk about an “NFT Staircase” for digital brand building: ownership → utility → identity → community. A brand starts by creating core NFT assets and giving people ownership of them; then, it builds utility on top of them. High-quality utility drives repeated engagement with the assets and reinforces the extent to which people personally identify with the assets and their associated brand. NFTs also provide natural mechanisms for holders to connect with each other and with the brand itself, reinforcing their brand enthusiasm and potentially becoming brand evangelists; this community built around the assets can be a core source of value for an NFT project at scale.
  - (b) Yuga Labs, for example, launched the Bored Ape Yacht Club with a limited series of NFTs associated with cartoon ape images. Yuga soon built a variety of utility features on top of those NFTs, including exclusive digital and physical products and events. A token-gated community server on the communications platform Discord, in particular, enabled Bored Ape Yacht Club NFT holders to connect and communicate with each other. And the Bored Ape Yacht Club imagery soon became a source of self-identification for Bored Ape Yacht Club NFT holders, who coalesced into a global community of brand enthusiasts.<sup>80</sup> Many other NFT projects have followed similar digital brand-building business models; particularly well-known examples include Azuki,<sup>81</sup> GoblinTown,<sup>82</sup> Pudgy Penguins,<sup>83</sup> and SupDucks.<sup>84</sup>
  - (c) All of the aforementioned features can drive individuals’ decisions to purchase NFTs. Some individuals purchase NFTs principally for the sake of owning the NFTs themselves and their associated assets. Others purchase in order to gain access to the various forms of utility the NFT provides. In the case of digital brand NFTs, people often purchase for the sake of gaining access to the brand and associated holder community.
  - (d) In addition, some individuals and institutions explicitly purchase NFTs as investments, which they intend to trade over either short or long time horizons.
  - (e) These different sources of value are neither exhaustive nor mutually exclusive. For example, an individual might acquire an NFT primarily to own associated media assets or for a specific functional reason (such as to use it to gain access to an event), and later choose to resell it. Or alternatively an individual might purchase an NFT primarily as an investment, but enjoy the associated utility while holding the NFT.

<sup>80</sup>Kominers, Narayandas, and Herman, *Bored Ape Yacht Club: Navigating the NFT World*.

<sup>81</sup>Chiru Labs. *Azuki Website*. URL: <https://www.azuki.com/>.

<sup>82</sup>Truth Labs. *Goblintown Website*. URL: <https://goblintown.wtf/>.

<sup>83</sup>Pudgy Penguins. *Pudgy Penguins Website*. URL: <https://pudgypenguins.com/>.

<sup>84</sup>MegaVolt Corp. *SupDucks NFT Universe Website*. URL: <https://www.supducks.com/>.

- (f) Naturally, the reason for purchasing depends on the features and functions of the NFT itself. The value of an ownership-only NFT derives from the value of owning that NFT itself and any associated assets. By contrast, digital brand NFTs often derive most of their value from expanding utility, reinforcing identity, and driving community activity.
- (g) These close ties between digital brand NFTs and holders' personal identity and sense of community belonging are intended to encourage long-term holding practices. This is reinforced by public messaging and conversation around NFT holder identity. For example, it is common parlance to speak of a "forever PFP" as an NFT that one intends to hold and use as a profile picture indefinitely (see, Figure 12 for an example). This is often reinforced by airdrops of additional, related digital brand NFTs that serve to strengthen holders' connection to the brand community.



Figure 12: A Twitter user discussing purchasing their new profile picture NFT they intend to use forever.<sup>86</sup>

## How The StockX Vault NFTs Work

37. The StockX Vault NFTs serve primarily as a simple ownership record for an associated physical product, thus providing a new way to trade physical products through the StockX platform.

- (a) Each Vault NFT corresponds to a unit of a physical product (e.g., a pair of sneakers) that is stored centrally by StockX. As the Vault NFT website explains: “Each Vault NFT is tied to a physical product (as depicted on the NFT), which is stored in our brand new, climate-controlled, high-security vault [ . . . ] These exclusive StockX Vault NFTs connect coveted physical products with readily tradable digital tokens that track ownership of the physical product.”<sup>87</sup> The original website messaging for the Vault NFT was analogous, as shown in Figure 13.

Own the most popular releases digitally and start saving on fees (and closet space). Each Vault NFT is tied to the same physical item, stored in our brand new, climate-controlled, high-security vaults inside StockX facilities.

So if you're bullish on a shoe, consider investing in a Vault NFT. You take possession of the NFT immediately after the transaction is complete, meaning it is the fastest way to flip. And with no shipping costs, and market-leading low seller fees at a fraction of the cost, there's a lower hurdle for profitability.

Figure 13: A screenshot showing the original advertising for the Vault NFTs.<sup>88</sup>

- (b) Like with other NFTs representing ownership of physical assets, the linkage between the (digital) Vault NFT technology and associated physical assets is maintained by contract/terms of service. StockX guarantees the availability of the physical product associated with each Vault NFT, and the holder of any Vault NFT can redeem their NFT for the associated physical product at any time. Redemption entails the payment of processing and shipping fees, as well as associated taxes when appropriate, but—critically—does not require the NFT holder to make any further payment for the physical asset itself, as detailed in Figure 14.

<sup>86</sup>CheddaaBob. *Forever PFP*. Mar. 2023. URL: <https://twitter.com/CheddaaB/status/1638691929000128512>

<sup>87</sup>This text quoted here is as of April 23, 2023. However, effectively identical statements appeared prominently on the Vault NFT landing page as early as January 18, 2022 (which is the earliest capture of the page available via the Wayback Machine: “Each Vault NFT is tied to the same physical item, stored in our brand new, climate-controlled, high-security vaults inside StockX facilities. [ . . . ] These exclusive NFTs connect coveted physical products with investable digital assets, from sneakers to creators to experiences and more.” (see <https://web.archive.org/web/20220118181316/https://stockx.com/lp/nfts/>).

<sup>88</sup>NIKE0000244.

- iii. **Fees.** Through January 31, 2023, the Vault Services will be provided free of charge until and unless you elect to have Stored Items shipped to you or you sell them to another buyer via the StockX platform. Beginning February 1, 2023, StockX will charge you a monthly fee for the provision of the Vault Services equal to .15% of the value of each Stored Item that you own, with a minimum monthly charge of ten (10c) cents for each trading card and one (\$1) for each pair of sneakers or other Stored Item. In the event you elect to have Stored Items shipped to you, you will pay the withdrawal fees, shipping costs and associated sales tax as set forth in these Vault Terms and the FAQs, as applicable. Note that StockX may charge you additional fees in the future for using the Vault Services beyond a certain amount of time, which will be notified to you in the FAQs. If such additional fees are introduced, you will have an opportunity to receive shipment of your Stored Items before such fees will apply.
- iv. **Delivery.** In the event you elect to have a Stored Item shipped to you, you will pay all applicable shipping fees, withdrawal fees and sales tax as set forth in these Vault Terms and the FAQs. You may elect to have Stored Items shipped to you at any time following March 1, 2022, by submitting a Redemption Request form, located in the FAQs. Please note that delivery may take as long as forty-five (45) days in certain cases, and StockX will not be liable to you for any delay in delivery. Upon electing to have the Stored Items delivered, the corresponding Vault NFT will be permanently removed from your portfolio and from circulation.

Figure 14: A screenshot from StockX’s NFT Terms of Service, detailing the fees paid when redeeming a Vault NFT.

- (c) As a result, ownership of a Vault NFT serves as a direct proxy for ownership of the associated physical product. Anyone holding a “StockX Vault NFT Nike SB Dunk Low Ben & Jerry’s Chunky Dunky – US M 10,” for example, is the owner of a physical pair of Nike SB Dunk Low Ben & Jerry’s Chunky Dunky shoes, in U.S. Men’s size 10, that is held securely in StockX’s Vault storage. Alternatively, anyone holding a “StockX Vault NFT LeBron James 2008 Topps #23 – PSA 9” is the owner of a physical PSA 9-graded LeBron James 2008 Topps #23 trading card that is held securely in StockX’s Vault storage.
  - (d) Each Vault NFT is linked to a representative image of the associated physical product, along with some unifying layout and StockX branding elements that serve to create visual consistency across the different Vault NFT images.
  - (e) In the language of the utility framework described above, the opportunity to redeem a Vault NFT for the associated physical product is the “default utility” of the Vault NFT.
38. The physical product categories covered by Vault NFTs correspond to established product categories on the StockX platform, such as sneakers, trading cards, watches, skate decks, and models/figurines (Figure 15).



Figure 15: A collage of the images of examples from each product category offered via StockX Vault NFTs, as well as the “How it Works” image associated with the sneaker Vault NFT.

39. At a technical level, Vault NFTs are minted by StockX on the Ethereum network, using the ERC-1155 standard, as part of the 0x9212C3E33eafb390D0d215950BD8bea1fCC24324 contract, viewable on Etherscan at <https://etherscan.io/address/0x9212c3e33eafb390d0d215950bd8bea1fcc24324>.
- (a) As already described above, the ERC-1155 standard makes it possible to generate a number of distinct NFTs, each of which is available in individually substitutable units. This is like with baseball (or Pokémon) cards, where cards representing different players (or monsters) are individually distinct, but two copies of the same card in the same condition are considered identical. And indeed, this method is literally used for Vault NFTs associated with Pokémon cards. For example, there are 10 editions of the “StockX Vault NFT Charizard-Holo 1999 Pokemon TCG Base Set #4/102 (PSA 9)” (Figure 16), with associated blockchain records viewable at <https://etherscan.io/nft/0x9212c3e33eafb390d0d215950bd8bea1fcc24324/9359012371217687000>.



Figure 16: The StockX Vault NFT image representing one of the physical PSA 9-graded Charizard Pokemon cards stored in the StockX Vault.

- (b) If the StockX Vault contains multiple copies of a given pair of sneakers, trading card, or other collectible, StockX can issue multiple identical associated NFTs. Using the ERC-1155 standard, StockX can issue a separate copy of the Vault NFT for each unit, and, moreover, is able to issue all such copies through a single batch transaction (as StockX in fact did—see the transaction records at <https://etherscan.io/txs?a=0x9212c3e33eafb390d0d215950bd8bea1fcc24324>). For a concrete example: if StockX were to add three pairs of Air Jordan 4 Retro White Oreo – US M 10 to its Vault storage unit, it would issue three copies of the “StockX Vault NFT Air Jordan 4 Retro White Oreo – US M 10.” Accordingly, the ten “StockX Vault NFT Charizard-Holo 1999 Pokemon TCG Base Set #4/102 (PSA 9)” Vault NFTs described and pictured above correspond to 10 distinct PSA 9-graded Charizard cards held in StockX Vault storage.
- (c) Redemption of a unit from the StockX Vault storage unit requires surrendering the associated NFT, so the number of units of each NFT in circulation corresponds precisely to the number of units of the physical product available in the StockX Vault storage unit. Upon redemption, StockX removes the associated Vault NFT from circulation within the StockX marketplace (but, at least at present, maintains it in its custodial wallet on the Ethereum blockchain).

40. Vault NFT transactions currently occur off-chain (i.e., not on a blockchain) with StockX maintaining an internal, digital ledger.

- (a) To purchase a Vault NFT, a user follows similar steps to what they would do in any online store. The buyer searches for the product they wish to purchase—in this case, a particular Vault NFT—selects it, and then either places a bid or buys it for the price of the lowest current ask. The user is then prompted to fill out the standard billing and credit card information, and then agree to the terms, conditions, and disclaimers. Once a Vault NFT is purchased, the image associated with the Vault NFT is visible in the holder's private StockX NFT Portfolio within the StockX user interface. Figure 17 demonstrates the buying process.

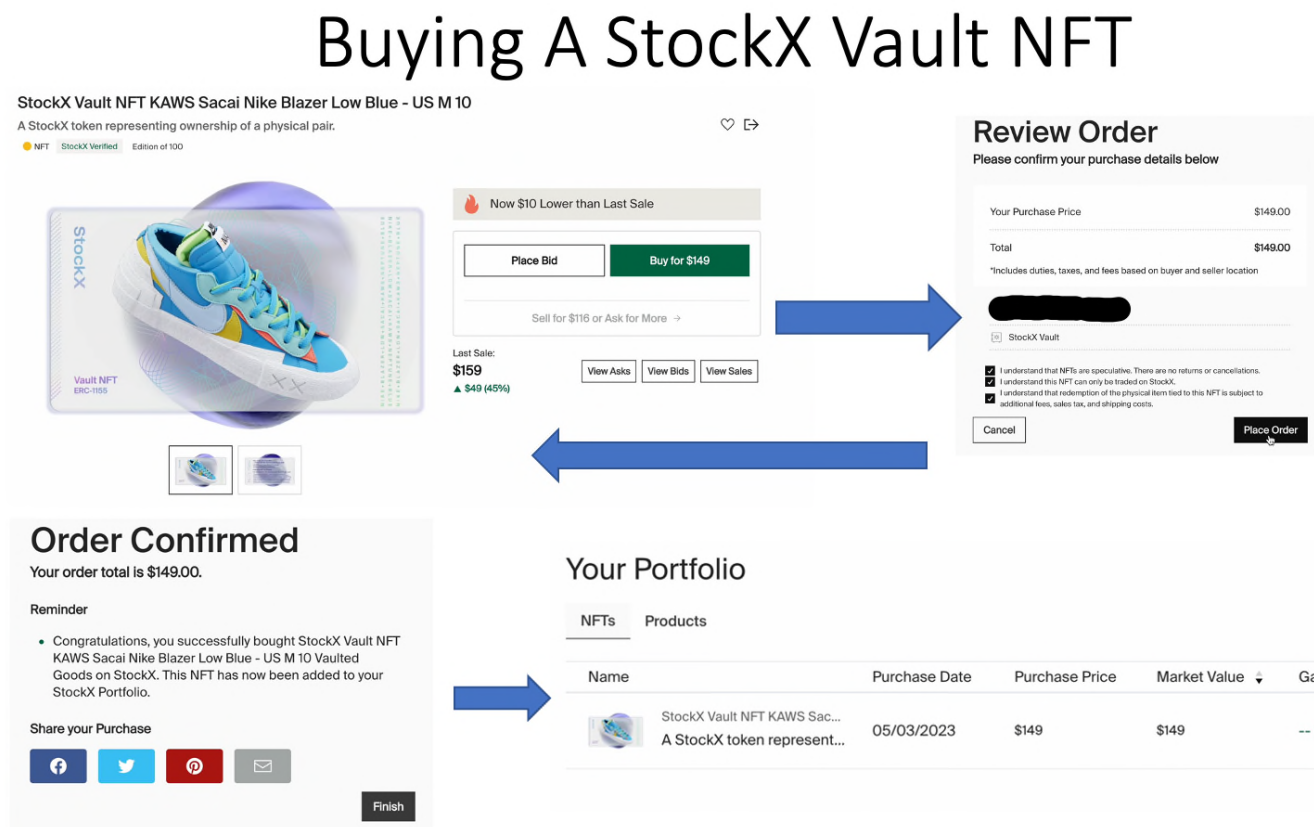


Figure 17: Screenshots showing the process of buying a StockX Vault NFT.

- (b) To sell a Vault NFT a user owns, that user can click “sell” next to the NFT on their NFT Portfolio page. They are then prompted to establish a payout method—like PayPal, Venmo, or a bank to receive money—and are then able to either sell at the current highest bid or place an ask for whatever price they wish. After agreeing to the sale terms and conditions, the item is either sold or listed for sale, depending on which option the seller chose. Figure 18 demonstrates the sale/listing process.

# Selling a StockX Vault NFT

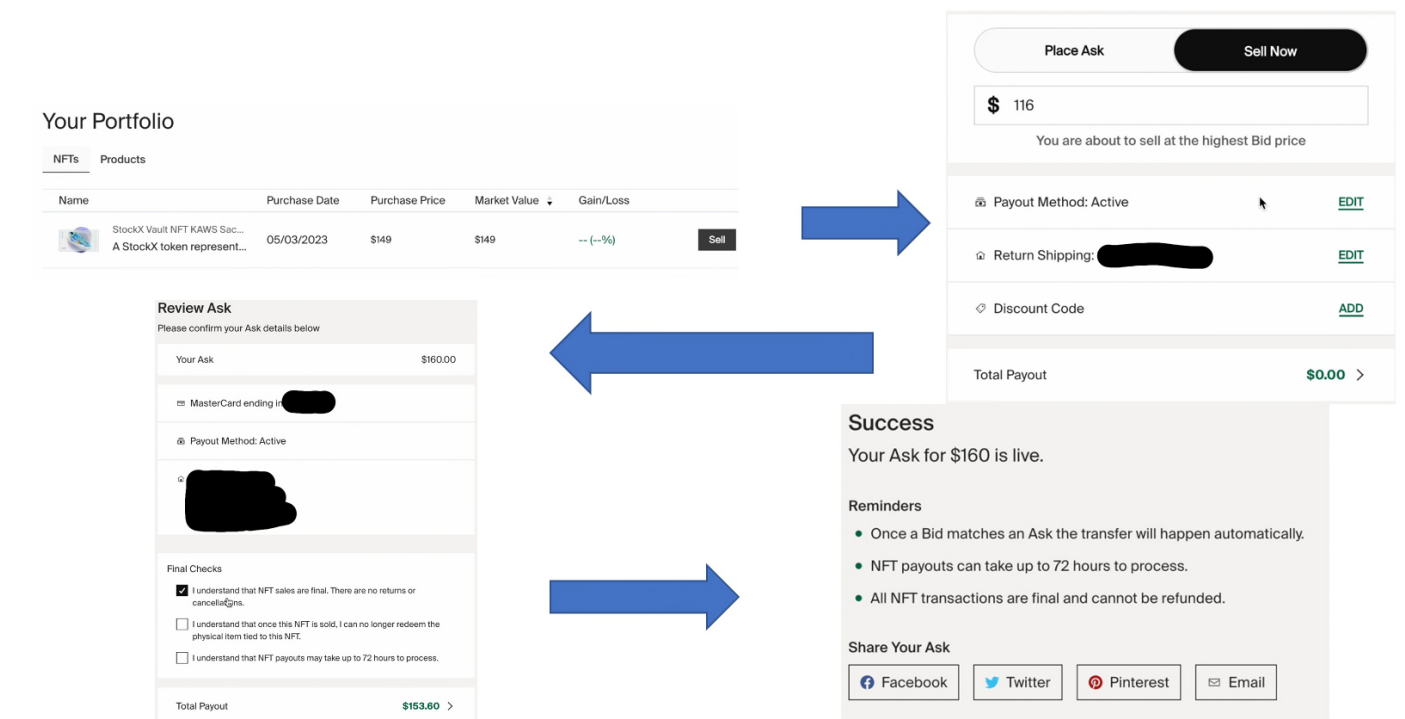


Figure 18: Screenshots showing the process of selling/listing a StockX Vault NFT.

41. Thus overall, in terms of product design and implementation, the Vault NFTs are a classic example of the use case of an NFT representing ownership of a physical product.
- And indeed, the Vault NFTs are similar to many of the physical-backed NFT projects described above. The Vault NFTs use ERC-1155 tokens to represent multiple units of the same product, just like with the Azuki “Twin Tigers Jacket”<sup>89</sup> and the RTFKT/Nike “RTFKT Clone X forging SZN 1” NFTs.<sup>90</sup> Meanwhile, the linkage of Vault NFTs to a physical asset stored in vault storage corresponds to the design of BlockBar and BAXUS.<sup>91,92</sup> Moreover, in all of the examples just referenced, the NFT is associated with a representative image of the associated product, just as the Vault NFTs are.
  - As we discuss in more detail below, the use of a centralized ledger in the Vault NFT marketplace design lines up with the design of centralized crypto trading exchanges such as Coinbase, as well as the trading card “Vault” implemented by eBay.<sup>93</sup> And more broadly, the use of a custodial wallet with a streamlined, e-commerce style checkout process aligns with Coinbase’s and eBay’s systems, as well as those of DraftKings<sup>94</sup> and NBA Top

<sup>89</sup>Labs, *Twin Tigers Jacket - Collection*.

<sup>90</sup>RTFKT, *RTFKT Clone X forging SZN 1 (PRE-FORGE) - Collection*.

<sup>91</sup>BlockBar, *Blockbar.com: How it Works*.

<sup>92</sup>BAXUS, *BAXUS Website*.

<sup>93</sup>eBay, *Vault Enrollment: Introducing the eBay Vault*. URL: <https://www.ebay.com/vault>

<sup>94</sup>DraftKings, *Who maintains custody of each NFT purchased on DraftKings marketplace? (US)*. URL: <https://web.archive.org/web/20230205051001/https://help.draftkings.com/hc/en->

Shot.<sup>95</sup>

- (c) Like in other instances with custodial wallets, the Vault NFTs were sold solely through product listing pages on the StockX marketplace. StockX's Vault NFT pages were highly similar to StockX's product display pages for the corresponding physical products, where a customer would go if they wanted to purchase the physical good directly. The format and layout of the two pages were essentially identical, with changes to the associated image that distinguish the Vault NFT from the physical shoe to show consumers that only the NFT would be delivered upon Vault NFT purchase, rather than the shoe itself. There were also small wording differences for the same purpose. As shown in Figures 19, 20, and 21, StockX's product pages for the Vault NFT and the sneaker that would be physically delivered are otherwise highly similar.

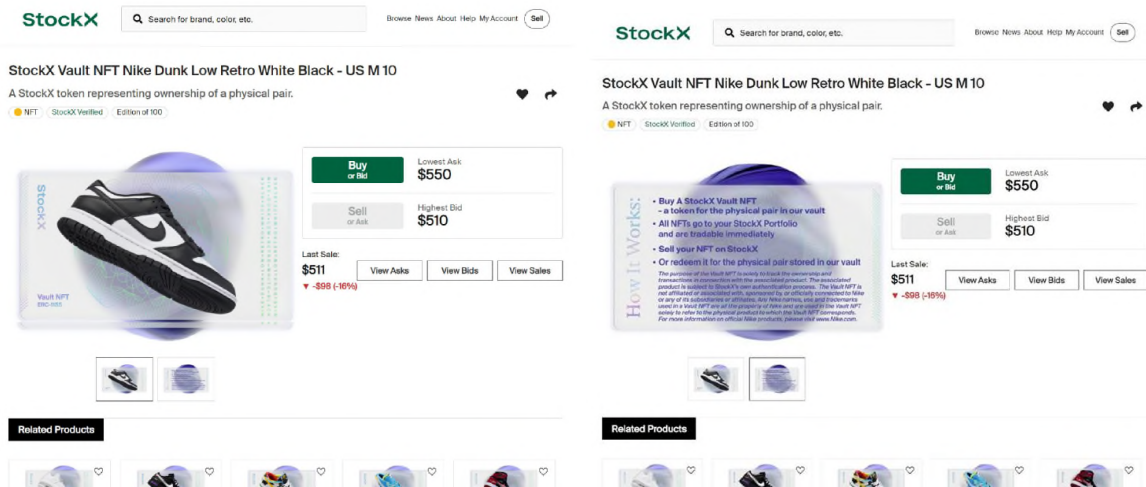


Figure 19: StockX Vault NFT product page from February, 2022.<sup>96</sup>

us / articles / 4404934462227 - Who - maintains - custody - of - each - NFT - purchased - on - DraftKings-Marketplace-US-.

<sup>95</sup>NBA Top Shot. *Send moments to non-custodial wallets: NBA Top Shot blog.* URL: <https://blog.nbatopshot.com/posts/send-moments-to-non-custodial-wallets>.

<sup>96</sup>NIKE0003858 & NIKE0003802.

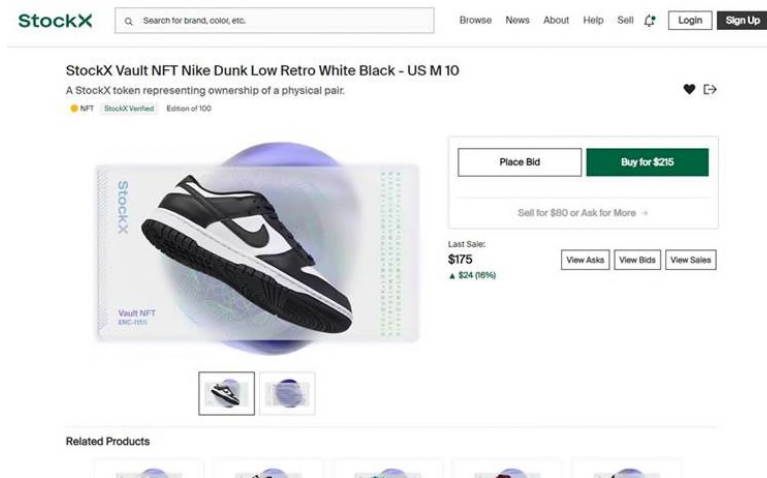


Figure 20: StockX Vault NFT product page from May, 2023.<sup>97</sup>

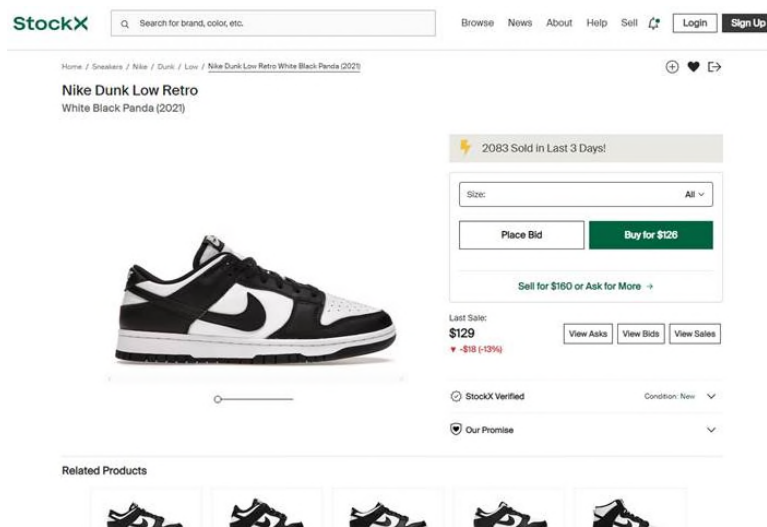


Figure 21: Standard StockX product page from May, 2023.<sup>98</sup>

## The Value Proposition of Vault NFTs

42. From a market design perspective, the Vault NFTs are an intuitive and economically valuable use of NFT technology. In particular, they serve to simplify and reduce friction in a collectibles trading/exchange process that already has been prevalent on the StockX platform.
  - (a) As already mentioned above, the physical product categories covered by Vault NFTs correspond to established product categories on the StockX platform. These physical product categories (and indeed, the physical product categories on the StockX platform, more

<sup>97</sup><https://stockx.com/retro-black-and-white-dunk-vault-nft>

<sup>98</sup><https://stockx.com/nike-dunk-low-retro-white-black-2021>

broadly) represent collectibles. People sometimes buy such items for the purpose of their own use and enjoyment. For such buyers, the Vault NFT model is unlikely to be attractive, because obtaining the physical product is essential to those buyers' intended use. However, many people also acquire these assets as investments, with an eye towards potentially reselling them in the future. For those buyers, mechanisms like the Vault NFTs that facilitate storage and later resale have a clear value proposition.

- (b) In particular, many StockX buyers are regularly in the habit of acquiring collectible assets on StockX and later reselling them on the platform. Some users are even professional traders who acquire assets via StockX at scale, with the express intent of later reselling them on StockX. This has been a core use of the platform since at least 2016.<sup>99</sup>
- (c) However, there are significant market and environmental inefficiencies inherent in reselling assets purchased on StockX using the traditional purchase model. In particular, to account for the verification services StockX provides in connection with each transaction, the asset must be transported four times—shipped from the seller to StockX and then from StockX to the initial buyer at the time of purchase, and then from that buyer, now seller, to StockX, and then to the second buyer in connection with the resale. There are risks of damage or theft during each transit stage; moreover, shipping is both expensive and environmentally costly. Moreover, there are inefficiencies in the need for repeat verification as the product changes hands. StockX verifies each product sold via its platform. This means that the verification process that was completed for the initial sale must be conducted a second time in advance of resale, because the asset's quality or condition may have changed while it was in the possession of the most recent purchaser. And finally, there are inefficiencies associated with storage itself. The user must store the asset between initial purchase and subsequent resale—and users typically do not have access to the quality of storage facilities available to a large marketplace platform, let alone at economies of scale.
- (d) Vault NFTs enable StockX users to acquire ownership of, and subsequently trade, the associated physical assets without any of the aforementioned inefficiencies. With Vault NFTs:
  - The physical assets are stored in StockX's own climate-controlled Vault storage unit, leveraging economies of scale and saving users from having to provide their own storage.
  - Because the physical assets remain in StockX's control the entire time, they do not need to be re-authenticated each time they are traded.
  - The physical assets are shipped only when an end-user decides to take possession of the physical asset by redeeming the associated NFT. This can save many rounds of shipping. For example, the "StockX Vault NFT Air Jordan 4 Retro White Oreo – US M 10" has seen fifty trades between March 19th 2022 and April 24th 2023 – an average of one resale per two tokens, corresponding in effect to 100 saved shipping fees. While of course it is possible that there would have been fewer trades had physical shipping and reauthentication of the shoes been necessary, that is part of the point of the Vault NFT system. By storing Air Jordan 4 Retro White Oreo shoes

<sup>99</sup>Chiara Farronato et al. *StockX: The Stock Market of Things*. Harvard Business School Case 620-062. URL: <https://hbsp.harvard.edu/product/620062-PDF-ENG>.

centrally and issuing associated NFTs, StockX reduces transaction costs in a way that both improves the efficiency of trades that would have occurred otherwise and enables new trades to occur.

- (e) Moreover, the Vault NFTs provide a particularly natural and intuitive inventory system through unified digital asset records.
  - (f) Thus, Vault NFTs enable the trade of physical assets on the StockX platforms in a way that is simpler, less costly, and less time-consuming than the previously available mechanisms for such trade. From an economic perspective, reducing friction in the market in this way should lead to increased efficiency, making it more likely the assets will be sold to those with the greatest demand at any given point in time. Moreover, Vault NFTs lower the complexity of becoming a trader of the associated assets in the first place, which again should increase the overall economic efficiency of the market.
43. Overall, in addition to being similar to other NFT products for simplifying trading physical assets, the Vault NFTs are closely analogous to services that other platforms such as eBay are providing for the same purpose. At a high-level, StockX's Vault NFT program is also similar to the way in which marketplaces organize the trade in commodities such as lumber or oil.
- (a) eBay has a similar service to the StockX Vault. Whenever a trading card is purchased on eBay, the owner may opt to send it to the "eBay Vault," where it is freely stored until a user chooses to withdraw it. While a card is in the eBay Vault, the current owner of that card may still list and sell it on eBay. The eBay Vault thus allows for a cheaper and simpler way for collectible traders to store and protect cards, as well as a more seamless resale experience that avoids the need for back-and-forth shipping. Additionally, eBay authenticates all cards that enter its Vault. Thus, the eBay Vault design serves a marketplace role closely analogous to that of the StockX Vault: providing storage and protection from theft, damage, or loss; as well as easing the sale process and reducing the need to have cards authenticated repeatedly. While, to my knowledge, no blockchain record is used in the eBay Vault system, the internal records representing each card stored in the eBay Vault are, in effect, acting in the same way as non-fungible tokens recorded on a private ledger.<sup>100</sup>
  - (b) More generally, commodity trading has a long and rich history of using ledger records to enable the efficient trade of goods that a given trader does not have in their own physical possession. There are many different financial instruments designed to give various exposures to physical goods without the complications of the physical possession of those goods. Among these financial instruments are futures contracts, where a promise to sell a commodity at a certain price on a certain date is created and that contract can then itself be sold, without having to move the underlying physical commodity. Moreover, in futures markets, the underlying units of the commodity are typically stored in approved centralized facilities, and the futures contract itself can often be settled via exchange of a "warehouse receipt" certifying ownership of the stored commodity units without having to deliver the commodity units themselves. This is again quite similar to the way that the StockX Vault NFTs represent individual units of the associated collectibles stored in a centralized facility. And this is not a new phenomenon—as far back as 4000 BCE in

<sup>100</sup>eBay, *Vault Enrollment: Introducing the eBay Vault*.

Sumeria, farmers would write out promises to deliver goats on clay tablets—although this is more akin to a futures contract, unlike the immediate ownership conveyed by a Vault NFT.<sup>101</sup>

44. As the examples just mentioned illustrate, trading services similar to the StockX Vault—in which goods are held centrally and then traded among parties according to ledger records—have existed for decades. StockX could have implemented such a system for trading on its platform prior to the existence of NFTs, or without NFT technology. However, NFTs provide a particularly intuitive and efficient way to implement such a service.
  - (a) The current implementation, in which Vault NFTs are traded on a centralized ledger on the StockX platform, relies on an internal StockX database to record who holds which Vault NFTs—or equivalently, who has the right to claim a unit (or units) of a given collectible in the StockX Vault storage unit. Such a database could be created and maintained independently of the existence of Vault NFTs, to implement a similar service.
  - (b) However, NFTs provide a superior technology for several reasons. First, because Vault NFTs are recorded on a public blockchain, it can be made possible for third parties to audit how many of each type of Vault NFT are in circulation independently of StockX, thereby increasing transparency of the market.<sup>102</sup> An even greater transparency improvement could be made by adjusting the transaction processing from an internal ledger to processing on a blockchain, and then trade and potentially Vault NFT pricing could also be made fully public and auditable.
  - (c) In addition, working with NFTs on the Ethereum network provides the option for StockX to eventually allow trade in the Vault NFTs on outside marketplaces rather than just on the StockX platform. This again would serve to provide economic efficiency benefits, both by expanding potential market access to the products beyond just the users of the StockX platform, and by enabling prospective buyers and sellers to actively choose the platform on which they wished to exchange (which in turn can lead to virtuous platform competition).<sup>103,104</sup>
45. Not only are NFTs a natural mechanism for StockX to use in its Vault trading system, but also the specific design decisions StockX made in the implementation of the Vault NFTs particularly make sense for this application.
  - (a) As already described, the use of the ERC-1155 token standard is a natural choice for NFTs representing discrete but substitutable units of limited-supply physical products. This is because the individual units of an ERC-1155 token can be made to directly correspond to the individual units of the associated physical asset.

<sup>101</sup>Jasodhara Banerjee. “Origins of growing money”. In: *Forbes India Magazine* (Jan. 2013). URL: <https://www.forbesindia.com/printcontent/34515>.

<sup>102</sup>As of this writing, the total number of units of each Vault NFT that had been minted was publicly visible, but because the transaction ledger, including redemptions, was entirely internal to the StockX platform, the number of each token still in circulation was not yet reflected on-chain. But this would be an extremely simple functionality to add.

<sup>103</sup>Christian Catalini and Scott Duke Kominers. “Can WEB3 Bring Back Competition to Digital Platforms?” In: *CPI TechREG Chronicle* 2.2 (2022), Article 6.

<sup>104</sup>John William Hatfield and Scott Duke Kominers. “A Simple Theory of Vampire Attacks”. Working paper, available at SSRN 4377561. 2023.

- (b) Given the nature of Vault NFTs and their tie to a physical product held by StockX, launching with a centralized, off-chain trading model hosted on the StockX platform was sensible for several reasons. The Vault NFT redemption process requires interfacing with StockX, which has custody of the physical product being redeemed, so that the company can remove the NFT from circulation and deliver the associated physical product. Moreover, StockX’s existing platform users—especially those engaged in frequent, active trading of assets on the StockX platform—are also the main target market for the Vault NFTs. Therefore, it makes sense for the Vault NFT marketplace frontend to be hosted on the StockX website. Meanwhile, a custodial model for managing trade in the Vault NFTs is a sensible way to make the market more approachable for consumers—again, especially StockX’s existing customers—who may be unaccustomed to blockchain technology, which is not otherwise a feature of StockX’s marketplace or trading model. And finally, maintaining a custodial model in a StockX-managed ledger avoids the complexity and transaction fees (i.e., gas fees) that would be associated with on-chain transactions. As StockX states in the #vault-101 channel of its public Discord server, “[b]ecause StockX maintains secure custodial authority of all NFTs, there are no gas fees on our platform.”
- (c) Similar models are used in various other NFT trading contexts, especially for companies launching NFTs whose customers are not necessarily familiar with blockchain technology. Both the DraftKings<sup>105</sup> and NBA Top Shot<sup>106</sup> initially used custodial wallet models for their NFT marketplaces, and then gradually expanded to allow non-custodial wallets. As mentioned above, even Ordinal NFTs, which are primarily of interest to the core NFT collecting and trading community, have been traded on partly or fully centralized ledgers—with a redemption option—to get around the complexity inherent in repeatedly transferring the Ordinal NFTs themselves.<sup>107,108</sup> And again, this centralized-ledger mechanism is also closely analogous to that used by centralized fungible token exchanges, such as Coinbase,<sup>109</sup> which manage most transactions through internal ledgers and settle to the blockchain only periodically.
- (d) The StockX Vault NFT market design is also consistent with best practices for platforms that are launching novel crypto marketplace products. As I described in my article with Jad Esber “Progressive Decentralization: A High-Level Framework,” “starting out entirely decentralized can be difficult or even totally impractical. Early design elements of a project or business often require more centralized vision and control. And centralization at early stages can make it easier to coordinate, launch, and rapidly iterate toward product-market fit [...] A given product can be segmented into ‘minimum decentralizable units’ (MDUs) that are mostly independent from one another, and then decentralized along each of these dimensions separately. MDUs might include the core team, external contributors, the tech stack, and so on [...]” In this case, StockX launched with decentralized storage of the Vault NFTs and their metadata, but with centralized trading. This is a highly sensible choice for a novel NFT product for which the precise trading protocols were still to be worked out, and whose prospective early adopters may not have had significant experience

<sup>105</sup>DraftKings, *Who maintains custody of each NFT purchased on DraftKings marketplace? (US)*.

<sup>106</sup>NBA Top Shot, *Send moments to non-custodial wallets: NBA Top Shot blog*.

<sup>107</sup>Ordinal Punks, *Ordinal Punk’s data*.

<sup>108</sup>Godwin, *Rodarmor ‘Ordinals’ Bitcoin NFTs spark trading volumes on the Bitcoin Network*.

<sup>109</sup>Coinbase, *Why can’t I see my transaction on the blockchain?*

with decentralized trading of crypto assets. In particular, it is best practice for startups and other companies to implement and test novel trading protocols and designs off-chain initially, especially to the extent that their product audience is already centralized in a given platform that can be used to host the test protocol.

## The Design of Vault NFTs Aligns with Their Role in the Market

46. The Vault NFTs are optimized for trading by design. They provide a mechanism for acquiring and exchanging ownership of the associated physical assets, while avoiding transaction costs inherent in interim storage, shipping, and re-authentication.
47. By contrast, to the extent that some StockX users purchase shoes or other assets on the platform for their own personal collections, the Vault NFTs are not well optimized for this use, relative to the option of simply buying those collectibles on StockX directly. While Vault NFT holders always have the option of redemption of the associated physical assets, if one's primary goal is to take possession of the physical asset, buying the asset directly is simpler.
48. Consistent with the foregoing, StockX has focused its messaging around the Vault NFTs' many benefits in simplifying and facilitating trade.

### What are Vault NFTs?

1/21/2022

Vault NFTs are digital tokens that represent ownership of physical items. Each Vault NFT is backed by a physical item held in StockX's custody, tied directly one to one via the blockchain. Any item in the StockX Vault is Verified Authentic.

This means that if you buy an edition of a Vault NFT, you are the owner of the corresponding physical good which is secured and stored in StockX's Vault.

You can trade that NFT to someone else, which will also transfer ownership of the corresponding physical good, you can hold it for any length of time, or you can redeem the item from the StockX Vault and take possession of the actual item.

All of this allows you to invest in current culture like never before, giving you the ability to own an item without ever taking possession of the item and without ever paying shipping fees. Plus you can sell it without having to send it to us and with fewer seller fees.

Figure 22: StockX's explanation of their Vault NFTs from 21 January 2022 in their FAQ section.

- (a) As illustrated in Figure 13 and Figure 22, StockX highlighted sources of value like saved closet space, fewer shipping fees, and a faster turn-around time for "flippers." These are all benefits that will help traders the most, which is consistent with long-standing goals of the entire StockX platform.
49. Furthermore, the core function of Vault NFTs as linked to physical assets is also evidenced by the features they lack. The Vault NFTs lack many of the features that typically contribute to holder identity and community formation around an NFT:

- (a) The Vault NFTs are managed and maintained in a way that is consistent with the way other digital (and physical) assets are managed on exchanges, i.e., through what is in essence a custodial wallet process, with an internal ledger maintained by the entity that holds the underlying assets. While this does not affect the fundamental nature of the Vault NFTs, it limits the ways in which the Vault NFTs may be used by holders.
- (b) Holders do not have direct access to, or control over, their Vault NFTs; they must use the StockX platform to access their Vault NFT portfolios even just to view the associated images. Moreover, at least at present, individual users' portfolios are non-public, in the sense that not even other StockX users can see them.
- (c) Vault NFT holders cannot, for example, link their Vault NFTs for verified display on Twitter or NFT gallery/metaverse platforms such as OnCyber.
- (d) Similarly, Vault NFT holders cannot in general use their NFTs for token-gated login on platforms such as Discord or tokenpoof. Even StockX's own Vault NFT-specific channel on StockX's Discord server relies on manual verification of Vault NFT holder status, rather than software-based token-gating. And furthermore, individuals can continue to participate in the Vault NFT-specific Discord channel even after they have traded their Vault NFTs. In effect, members of the Vault NFT-specific Discord channel constitute a community of StockX traders identified initially through their interest in the Vault NFTs, rather than a community built around a shared source of identity deriving from NFT ownership.
- (e) Moreover, StockX generally does not engage in NFT marketing strategies designed to promote holder identity formation around the Vault NFTs. For example, many NFT projects use their public social media channels to encourage their holders to engage with each other around their NFTs, and to use the associated images as profile or banner pictures on social media, as shown in Figure 23.

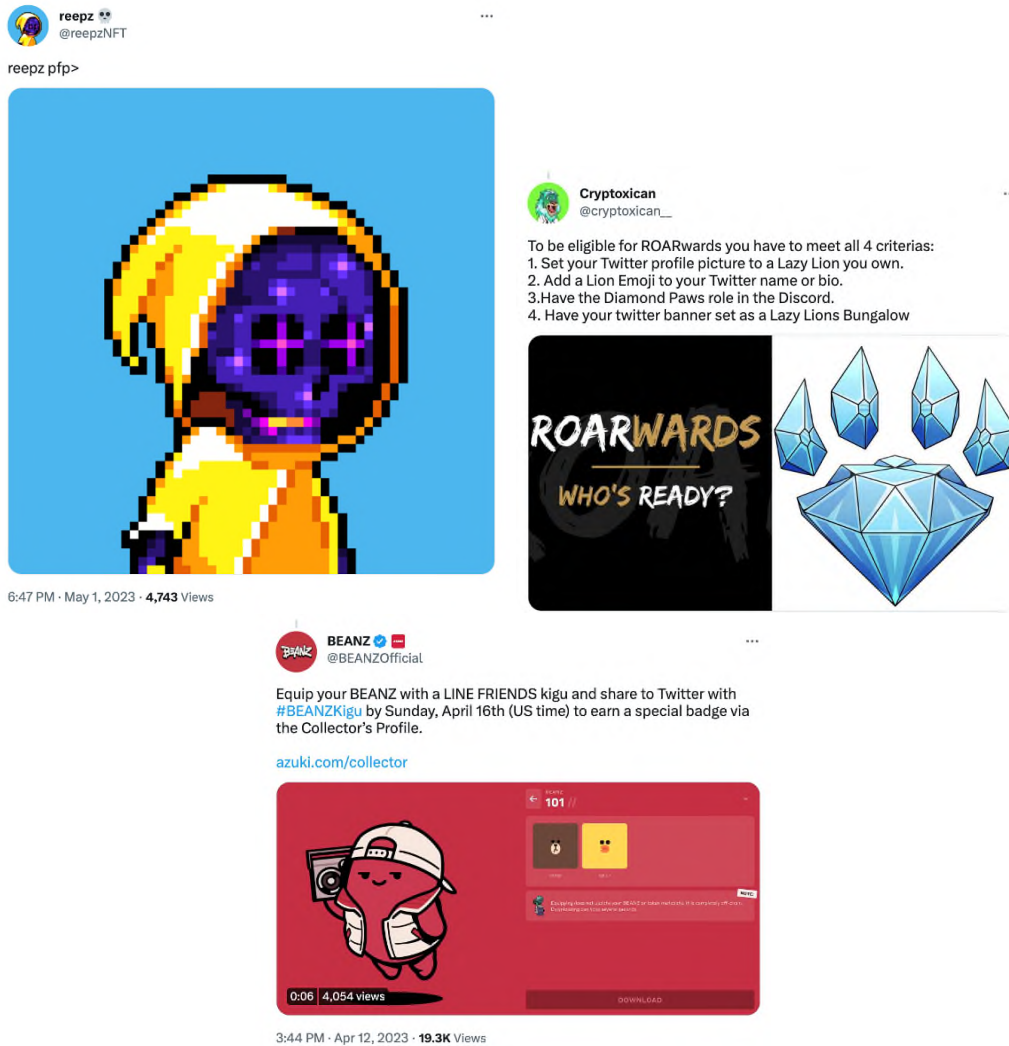


Figure 23: Reepz, Lazy Lion, and Azuki NFT Twitter posts encouraging their followers encouraging their followers to advertise their brand attachment by sharing the images associated with their NFTs.<sup>111</sup>

- (f) By contrast, StockX's social media engagement around the Vault NFTs is limited to announcements about when new Vault NFT products become available. Even the initial Twitter announcement about the program simply emphasized the underlying physical asset (Figure 24). Moreover, whereas digital brand NFT projects will typically explicitly encourage their holders to think of themselves as a “community” or “family,” StockX does not use this language in its communications around the Vault NFTs.

<sup>111</sup>Reepz. *Reepz pfp*. May 2023. URL: <https://twitter.com/reepzNFT/status/1653169220174360577>

Cryptoxican. *To be eligible*. Dec. 2022. URL: [https://twitter.com/cryptoxican\\_\\_/status/1603662572108283909](https://twitter.com/cryptoxican__/status/1603662572108283909)

Beanz. *Equip your Beanz*. Apr. 2023. URL: <https://twitter.com/BEANZOfficial/status/1646237893680328704>

*Disclosure: I hold Reepz NFTs.*

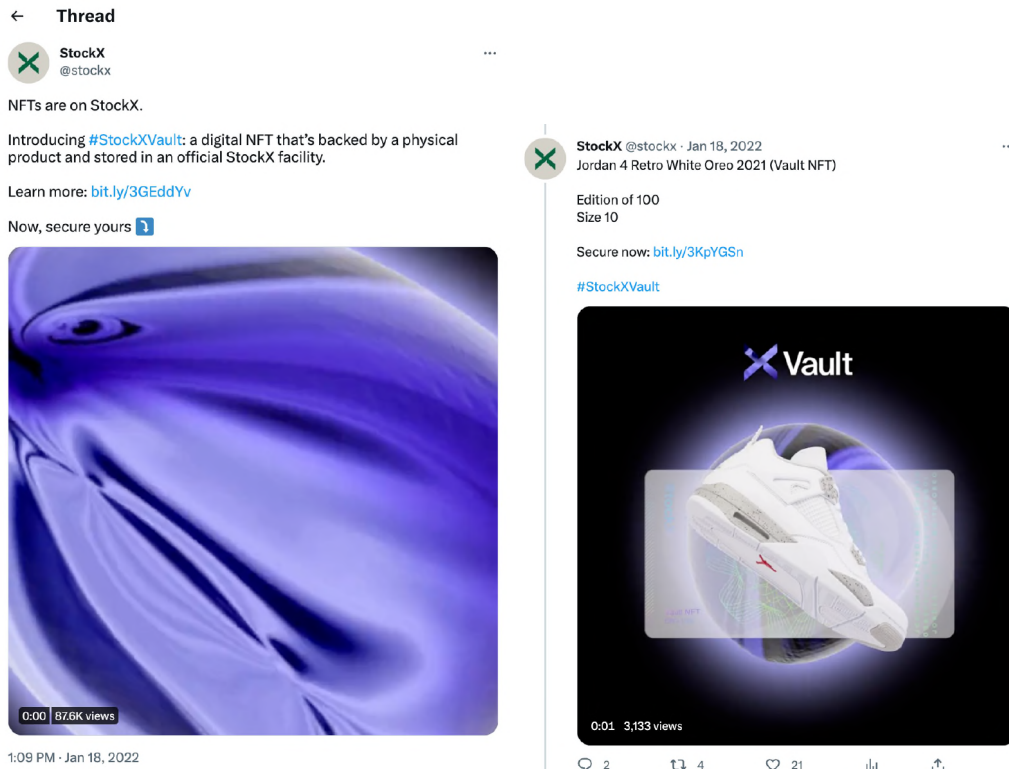


Figure 24: StockX's Twitter announcement of the StockX Vault NFTs.

- (g) Similarly, StockX generally does not encourage holders to become personally attached to their Vault NFTs; rather, they explicitly encourage holders to collect and trade. Again, StockX appears to be seeking to use the Vault NFTs to help cultivate and reinforce a “community of traders” on the StockX platform, which is consistent with the platform’s overarching vision “[t]o be the trusted global platform for consuming and trading current culture<sup>112</sup>,” and to serve as a “stock market of things” that facilitates active, liquid (“stock market-like”) trading in all manner of collectibles.<sup>113,114</sup> Long-term NFT holding simply for the sake of owning the NFTs (rather than for the purpose of long-term investment) would conflict with the repeated trading that is at the core of StockX’s platform. This is in sharp contrast to digital brand NFT projects that encourage people to find their “forever NFT” and become permanent NFT holders.
- (h) And StockX generally does not use its public social media accounts to re-share or otherwise promote messages that holders post about the Vault NFTs—again unlike many NFT projects, which actively seek to foster and elevate public engagement among holders.
50. Moreover, StockX has generally eschewed attaching utility to the Vault NFTs beyond the default utility of being able to redeem an NFT for the associated physical asset.
- (a) StockX has repeatedly emphasized that the Vault NFTs are not “experiential NFTs,” clarifying that both current and prospective holders should not expect the type of additive

<sup>112</sup><https://stockx.com/about/company/>

<sup>113</sup><https://stockx.com/about/company/>

<sup>114</sup>Farronato et al., *StockX: The Stock Market of Things*.

utility-based brand building common in many other NFT projects (Figure 25).<sup>115</sup>

## What are the rewards and benefits of owning NFTs on StockX?

2/25/2022

Owning certain Experiential NFTs on StockX may qualify customers for unique and exciting perks, products, experiences, credits and more. Rewards qualification may be based on one project or many projects, and can be determined based on the Experiential NFTs owned, the Creator, the number of account holders, self-selection (“burning”), or other factors.

For avoidance of doubt, Vault NFTs are not Experiential NFTs. Vault NFTs are digital tokens that represent ownership of physical items and, therefore, do not have any intrinsic value beyond that of the underlying physical good. Vault NFTs do not include unique experiences and benefits as a component of their value. However, owners of Vault NFTs may be eligible for certain incentives and rewards that StockX provides to its users from time to time for using StockX services.

Figure 25: An email StockX sent out on 25 February 2022, clarifying the difference between Vault NFTs and Experiential NFTs (NIKE0000952).<sup>117</sup>

The platform even explicitly distinguished a separate NFT series, “StockX Collective,” that was designed and marketed as a utility-based token that would have additive utility (Figure 26).<sup>118</sup>

StockX BOT 30-Jun-22 04:11 PM

@here **NEW for NFT Collectors** 🖼️👁️🖼️💥

Introducing #StockXCollective: our first-ever utility-based Token that awards exclusive deals and benefits.

Coming July 2022:

- ✅ \$14.95 off Shipping
- ✅ 20% off a single purchase
- ✅ Chance to win a rare grail
- ✅ and MORE

Figure 26: A Discord announcement by StockX detailing their StockX Collective NFTs.

<sup>115</sup>NIKE0000952.

<sup>117</sup>Prior iterations of StockX’s Terms & Conditions stated, in the section discussing StockX NFTs generally, that “in some cases, per the applicable Additional NFT Terms, StockX may automatically redeem your NFT for an Experiential Component, at its sole discretion, in which case StockX may remove the NFT from your portfolio and you will cease to own the NFT” (NIKE0000253). This language did not appear in the section of the Terms & Conditions specific to Vault NFTs. StockX later revised its Terms of Service to specifically state that automatic redemption was only relevant in connection with “experiential NFTs”—a category distinct from Vault NFTs (NIKE0000395; STX0160773).

<sup>118</sup>NIKE0064430.

- (b) Early on, StockX experimented with providing platform discounts and rewards to Vault NFT holders. For example, StockX briefly offered a series of giveaways for Vault NFT holders, including \$200 and \$250 StockX credits, physical sneakers, and a KAWS figure. I also understand from counsel that StockX at one time experimented with giving Vault NFT holders \$20 coupons for use on the StockX platform. However, StockX soon eliminated these benefits for Vault NFT holders. This is consistent with a view that the primary purpose of the Vault NFTs was to enable and encourage trade—and that any utility attached to the Vault NFTs (other than the default utility of being able to redeem the associated physical asset) might actually reduce trade by encouraging people to hold their Vault NFTs for their standalone benefits. Moreover, StockX regularly conducts giveaways and offers other benefits tied to its platform to customers, and the giveaways conducted in connection with the Vault NFTs appear consistent with these ordinary promotional efforts connected to StockX’s platform.<sup>119,120</sup>
- (c) Notably, the move to eliminate holder benefits is the exact opposite of what digital brand NFTs typically do—digital brand NFT projects generally seek to expand the utility of their NFTs in an ongoing manner, and at times face significant pressure from their holders to do so. Note also that StockX has never offered holders of the Vault NFTs any form of preferential access to or airdrop of new NFTs, which is a particularly common strategy used by digital brand NFTs to reinforce holders’ connection to the brand.
- (d) While StockX has occasionally provided giveaways through its Vault NFT Discord channel, these are not limited to current Vault NFT holders; rather, because the channel was not strictly token-gated as discussed above, they were open to anyone who has ever participated in the Vault NFT program. This differs from the standard practice in digital brand NFT projects—which generally token-gate their communities more strictly because they almost definitionally link community membership to NFT ownership. As described above, the StockX model of a Discord channel open to anyone who has ever held a Vault NFT, no matter how briefly, is more consistent with the creation of a community of individuals interested in collectibles trading in general, and more specifically, the distinct trading model represented by the Vault NFTs.
51. The foregoing analysis of the Vault NFTs’ lack of identity, community, and additive utility features indicates that while StockX is seeking to build a business around NFT collecting and trading on its website, it does not appear to be building a digital brand around the NFTs.
- (a) Moreover, Vault NFTs are serving their functional purpose as NFTs tied to physical assets, designed to facilitate trading. Those who understand the collectibles resale market have expressed significant positive sentiment around the Vault NFTs for the ease and efficiency they introduce to the resale market on the StockX platform. Figure 27 illustrates some examples.

<sup>119</sup>Alek Rose. “Win a prize with every purchase in the StockX Black Friday celebration”. In: *Highsnobiety* (Nov. 2022). URL: <https://www.highsnobiety.com/p/stockx-black-friday-sale/>.

<sup>120</sup>StockX. *StockX Promos Official Rules Page*. URL: <https://stockx.com/news/promotion-rules-page/>.



Figure 27: Two Twitter threads discussing the StockX Vault NFTs.<sup>121</sup>

- (b) And furthermore, the Vault NFTs appear to be successfully facilitating trade, with long-run pricing patterns consistent with market efficiency. Initial Vault NFT prices saw a spike, as happens with many novel NFT products as the market is discovering the value of the digital asset. (In this case, for example, traders may have had uncertainty about long-run demand for the Vault NFTs specifically, as well as the market premium for the liquidity Vault NFTs provide, and they may also have had uncertainty vis-à-vis whether Vault NFTs would feature additive utility.) Over time, however, the prices of most Vault NFTs under consideration converged to track closely with the value of the associated physical assets. For example, Figure 28 shows the sale prices of two Vault NFTs associated with the Kaws Sacai Nike Blazer Low Blue sneakers and the Air Jordan 4 Retro White Oreo sneakers over time. The blue dots show individual sale prices for the Vault NFTs, and the red lines track the concurrent sale prices of the same type of shoes on the StockX marketplace. (Shoe sales price data was only available through 31 July, 2022.) As the figures illustrate, we see convergence in the price of the Vault NFT to track the price of the corresponding physical good.

<sup>121</sup> AttentionToDetail. *stockx has officially entered NFT's*. Jan. 2022. URL: <https://twitter.com/AttentionToDe12/status/1483587034367340544>; sanj. *That is why they've built the StockX NFT vault*. Sept. 2022. URL: [https://twitter.com/bytebybit\\_/status/1571207969748013057](https://twitter.com/bytebybit_/status/1571207969748013057)

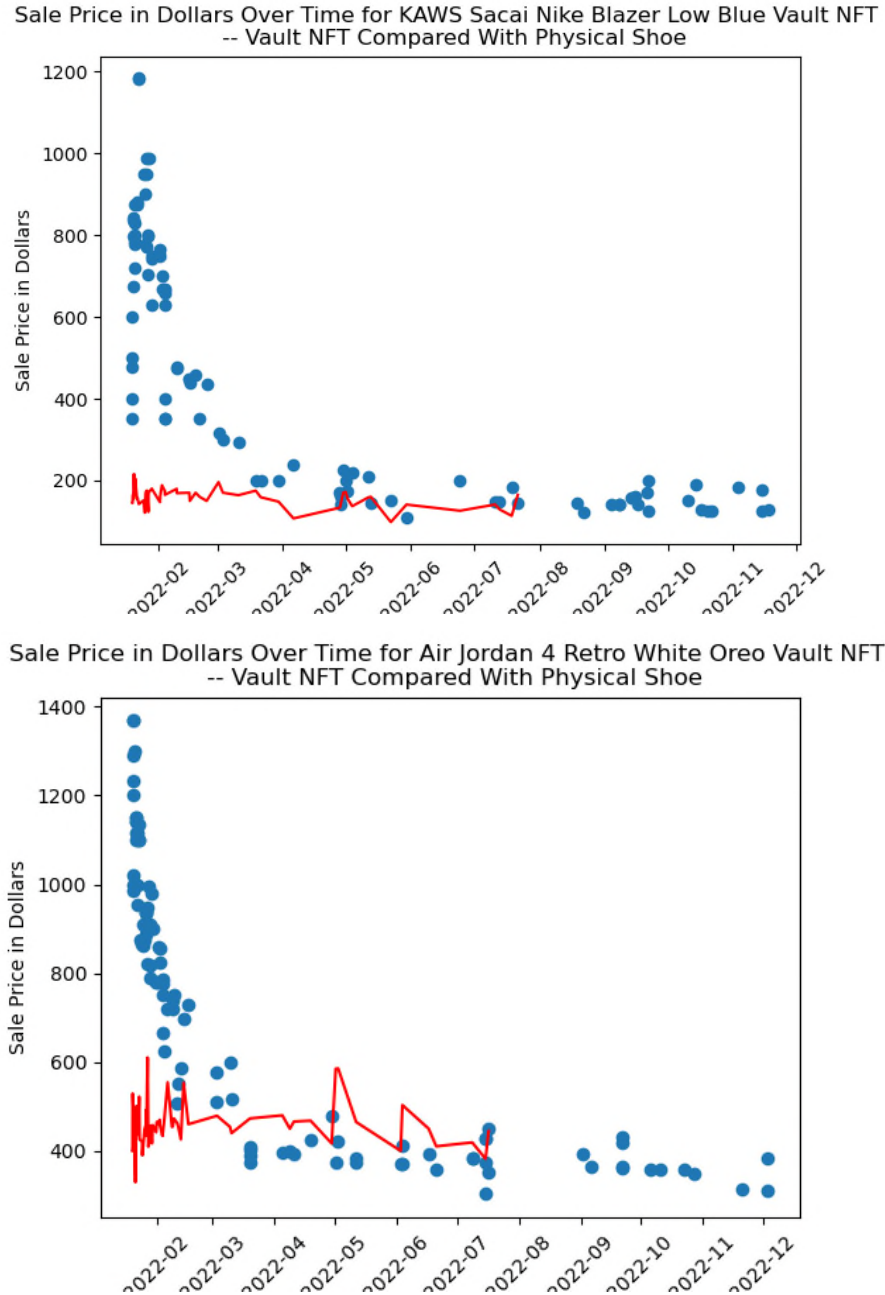


Figure 28: Graphs of price over time for the Kaws Sacai Nike Blazer Low Blue Vault NFT and the Air Jordan 4 Retro White Oreo Vault NFT. The red line represents the most recent prior sale price for the corresponding physical good (physical good price data ends 31 July, 2022). Data provided by Counsel in STX0806025 and STX0806026.<sup>123</sup>

52. All of that said, to the extent that the Vault NFTs have “digital brand” features, the digital brand in question is unambiguously that of StockX itself.

(a) StockX Vault NFT images and other media prominently display the StockX logo and/or

<sup>123</sup>See Appendix 1 for figure-generation source code.

the Vault NFT icon, which features a large “X”.

- (b) Because viewing one’s own collection and trading in the assets can be performed only after logging into one’s account on the StockX platform, interacting with the assets reinforces the user’s engagement with StockX. Likewise, Vault NFTs must be managed through the platform because StockX controls the digital wallets holding the NFTs themselves.
- (c) As already mentioned, the only benefits to Vault NFT holders to date have been inside of the StockX ecosystem. Similarly, community-building around the assets, to the extent that it exists, is entirely within StockX’s brand umbrella (e.g., in its Discord).
- (d) This is consistent with the way NFT creators typically provide utility benefits for holders based entirely in the creator’s product ecosystem. For example, *The Hundreds*’s NFT projects grant NFT holders early access and special discounts to *The Hundreds*’s products, access to events hosted by *The Hundreds*’s founders, and so forth.<sup>124</sup> Nike and RTFKT similarly tend to keep utility benefits within their ecosystem, for example, with holders of RTFKT CloneX NFTs receiving MNLTH NFTs via airdrop, which were then useful in gaining access to Nike CryptoKicks.<sup>125</sup>

## Comparing the Vault NFTs to Nike’s Digital Brand NFTs

- 53. Finally, to more fully understand and illustrate the position of the StockX Vault NFTs within the broader NFT marketplace, we examine them in comparison with the Nike/RTFKT digital brand NFT ecosystem. Overall, there are stark differences between the StockX Vault NFTs and Nike’s various digital brand NFTs along many dimensions by which NFT collections differentiate themselves in the marketplace.
- 54. First, the ways in which the parties’ respective projects are marketed differ.
  - (a) Often in NFT collections, there is a “reveal,” or some form of algorithmic transformation of the NFT that is unknown or uncertain to the NFT’s holder. The most common example is that many large collections are often minted in such a fashion that minters and early secondary-market purchasers of the NFT do not know the exact nature or relative rarity of their NFT until a later reveal date. This serves to generate hype and mystery within the community, and generate conversation amongst the holders after minting (and again after reveal) that carries on for some time. For NFT collections intent on building digital brands around their NFTs, this mystery builds community interest and intrigue, and public attention can entice others into Acquiring the NFTs as well.
  - (b) Nike and RTFKT regularly engage in such behavior. The cornerstone offering of RTFKT is the CloneX NFT,<sup>126</sup> a 3D digital avatar whose traits and appearance were revealed to users on a specified date after mint. Indeed, social media advertising by RTFKT played

<sup>124</sup>Disclosure: I hold *The Hundreds* NFTs.

<sup>125</sup>Andrew Hayward. “Nike and RTFKT reveal CryptoKicks-their first Ethereum NFT metaverse sneakers”. In: *Decrypt* (Apr. 2022). URL: <https://decrypt.co/98488/nike-rtfkt-reveal-cryptokicks-ethereum-nft-metaverse-sneakers>.

<sup>126</sup>Cathy Hackl. “The evolution of a metaverse brand: RTFKT’s Clonex Drops Today”. In: *Forbes* (Nov. 2021). URL: <https://www.forbes.com/sites/cathyhackl/2021/11/29/the-evolution-of-a-metaverse-brand-rtkfts-clonex-drops-today/?sh=303606356d62>.

into the uncertainty and mystery of the CloneX, teasing the distribution of traits and calling it “sneaky info” on the Twitter post shown in Figure 29.

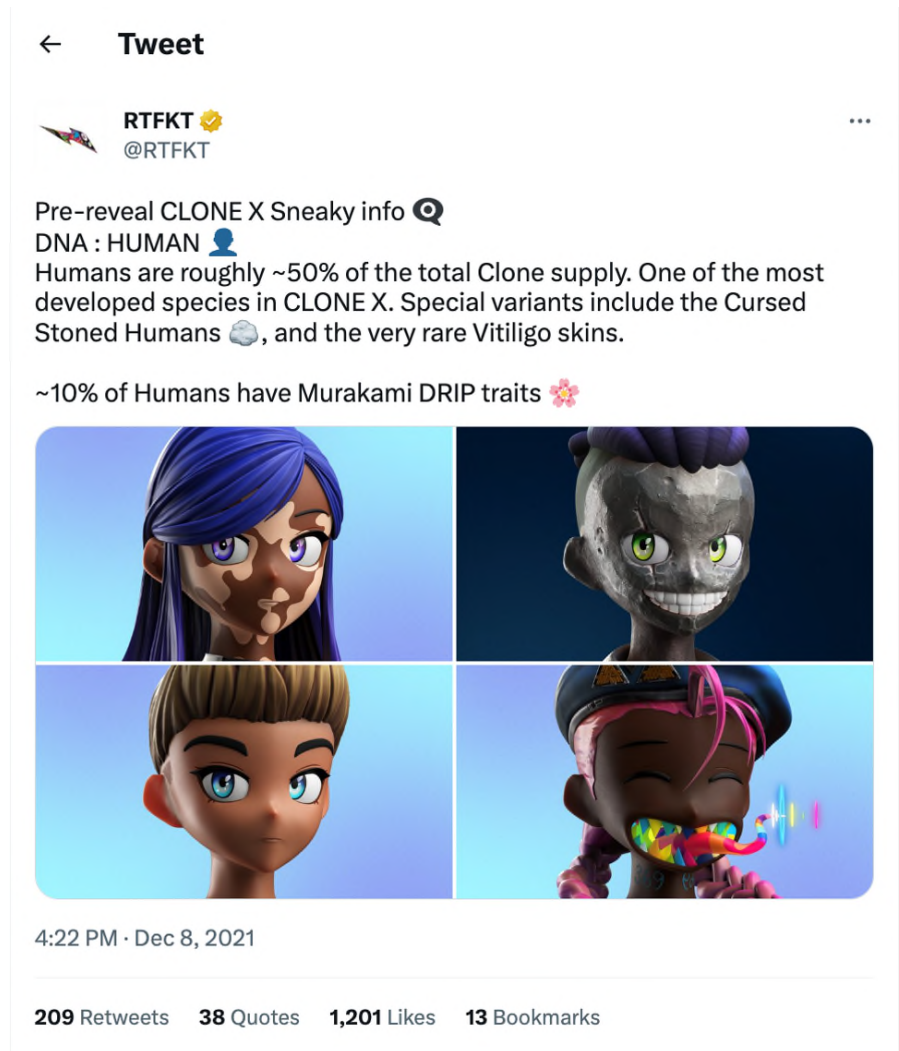


Figure 29: A pre-reveal teaser Tweet of the CloneX by RTFKT.<sup>127</sup>

- (c) Similarly, Nike and RTFKT’s most recent large offering, the MNLTH X, is an NFT with an associated image showing an opaque box, with the OpenSea description reading “Behold a mysterious MNLTH X that has appeared from a time thought lost.” Very few details are given, and even as of approximately five months later, the details of what is “inside” the MNLTH X have not been explained. This strategy of generating drawn-out interest by not immediately clarifying the utility of the offering encourages both ongoing buy-in and long-term ownership of the NFT. And both buy-in and long-term ownership are paramount for digital brand NFTs.
- (d) By contrast, StockX’s marketing for its Vault NFTs does not use this sort of obfuscation. StockX’s Twitter post announcing Vault NFTs contained a link fully explaining the system

<sup>127</sup><https://twitter.com/RTFKT/status/1468692367054151682>

(see Figure 13). The same Twitter thread also revealed the images behind all the NFTs as being just pictures of the items for which the associated NFTs could be redeemed.<sup>128</sup> And each type of NFT in the Vault NFT series is sold separately from the others. There is no randomness in the allocation; even at the time of the primary sale, a user could decide exactly which Vault NFT product they wished to purchase, and purchase that specific Vault NFT.

- (e) Furthermore, any ambiguity in the specifics of the Vault NFT offering was the subject of public discussion, and, instead of fueling ongoing speculation, StockX used this feedback to rapidly provide clarifications answering customer questions.<sup>129</sup>
  - (f) Additionally, as mentioned above, instead of marketing the Vault NFTs with messaging intended to encourage holders to become attached to their Vault NFTs, StockX explicitly messaged around trading and resale. As noted above, the marketing for the Vault NFTs highlighted benefits like “saving closet space” and being the “fastest way to flip,” (Figure 13) consistent with the goal of getting Vault NFT owners comfortable with actively and repeatedly trading their NFTs.
55. The form of user engagement around the StockX Vault NFTs and Nike/RTFKT NFTs also differs markedly.
- (a) For example, in many communities involving NFTs, there are channels for new users to post screenshots of NFTs they acquire, and receive congratulations from other users via online comments. For the StockX Vault NFTs, these introductions seldom focus on the imagery attached to the NFT, and often do not include it at all. Frequently a user will simply post a screenshot of the email confirming the purchase of the NFT without any part of the image included, and still receive the standard “fire emoji” reactions indicating congratulations (as shown below in Figure 30).

<sup>128</sup><https://twitter.com/stockx/status/1483501803182374922?lang=en>

<sup>129</sup>STX0102499

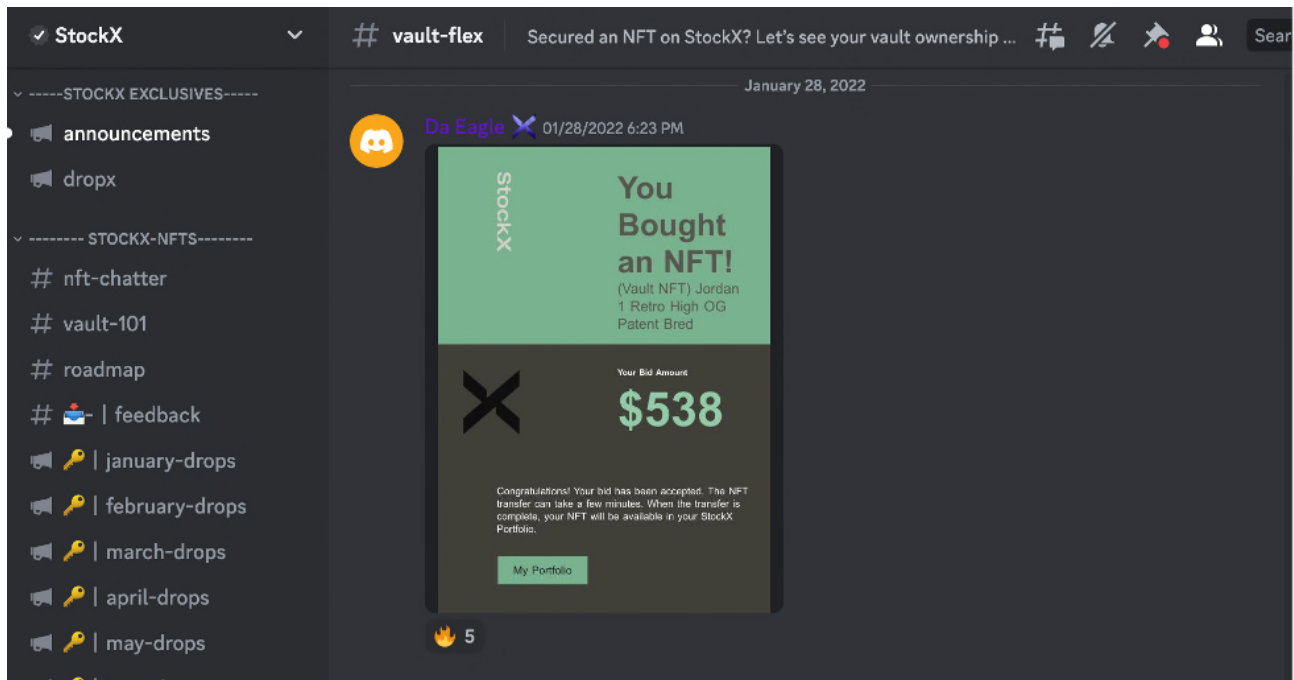


Figure 30: A user posting a screenshot of a StockX Vault NFT receipt in the #vault-flex channel.<sup>130</sup>

- (b) By contrast, in the context of digital brand NFTs, holders almost universally include a picture of the NFT's associated image when they announce an acquisition of the NFT, because, in some sense, that image (whose ownership was conveyed by the NFT) is the identity with which they are entering the community. CloneX holders very much do form this type of identity—see, for example, Figure 31—and use the images as representations of such. Importantly, the language of the post in Figure 31 cements that the purchase of this NFT is about joining a community, and ties user joshachaplin's identity specifically to Clone #18824. This sort of personal identification with the NFT—and indeed, even simply the sharing of the NFT images—is almost absent in the StockX Vault Discord and social media chatter. For StockX Vault NFT holders, it appears that the image is, at best, an afterthought, and users do not tie their identity to a specific Vault NFT.

<sup>130</sup>StockX Discord post from the #vault-flex channel, 28 Jan 2022.

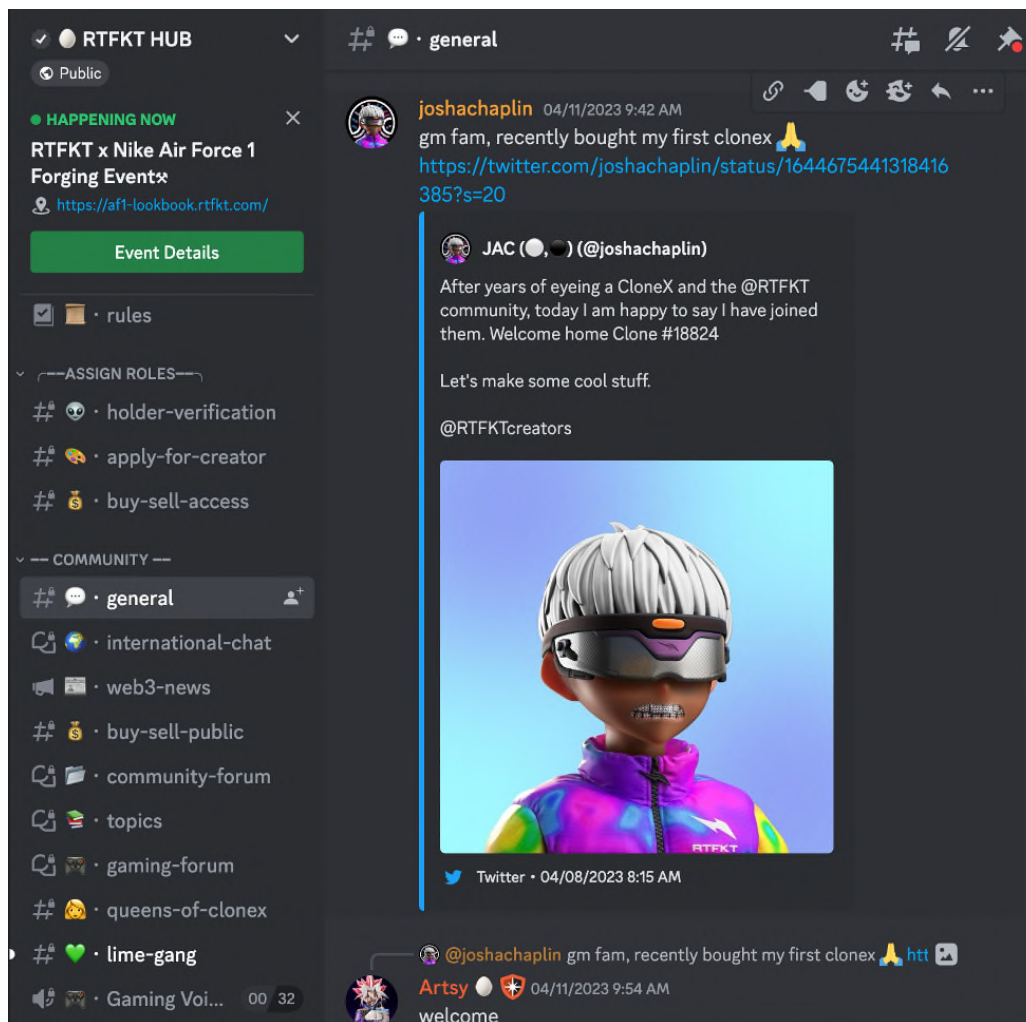


Figure 31: A user joining the CloneX community with a picture of their NFT.<sup>131</sup>

56. There is also a difference in language in how users talk about the Nike/RTFKT NFTs and the StockX Vault NFTs.

- (a) When selling or buying the RTFKT CloneX NFTs, users will frequently anthropomorphize the NFTs and talk about how they will either give the NFTs a “good home” or want to sell to someone who will (see Figure 32). This generally does not occur in the discussion of the StockX Vault NFTs. Importantly, though, it is not simply that users are more likely to anthropomorphize the humanlike images of the CloneX NFTs. In StockX social media channels, Vault NFT holders repeatedly discuss wanting to make sure that the underlying physical shoes go to a good home, and talk about their difficulty selling shoes to which they have become very attached (see Figure 33). Anthropomorphization certainly exists in the realm of shoes, but it is tied to the underlying physical asset, not the NFT (or any associated digital image or digital good).

<sup>131</sup>RTFKT Discord post from the #general channel, 11 Apr 2023.

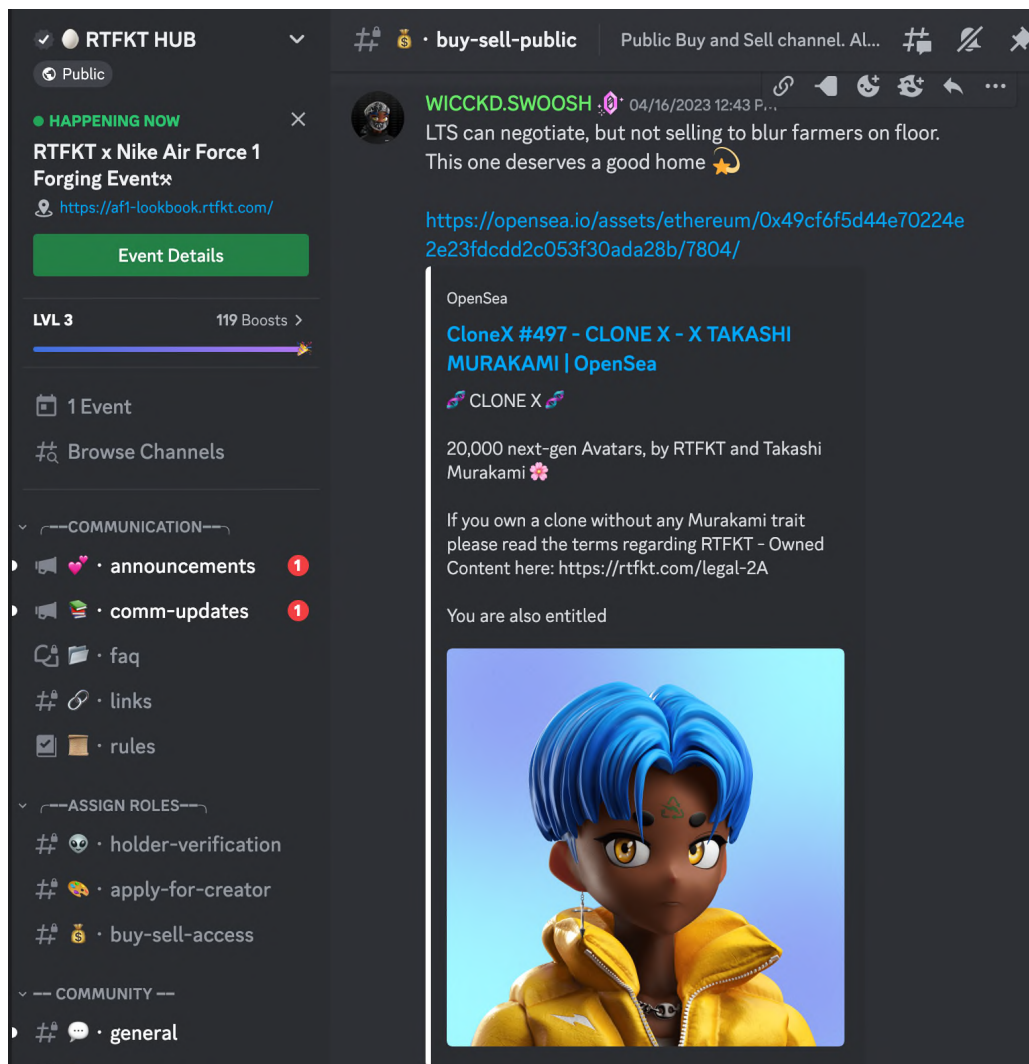


Figure 32: A user looking to sell their CloneX NFT only to someone they believe will adequately care for it.<sup>133</sup>

<sup>133</sup>RTFKT Discord post from the #buy-sell-public channel, 16 Apr 2023.

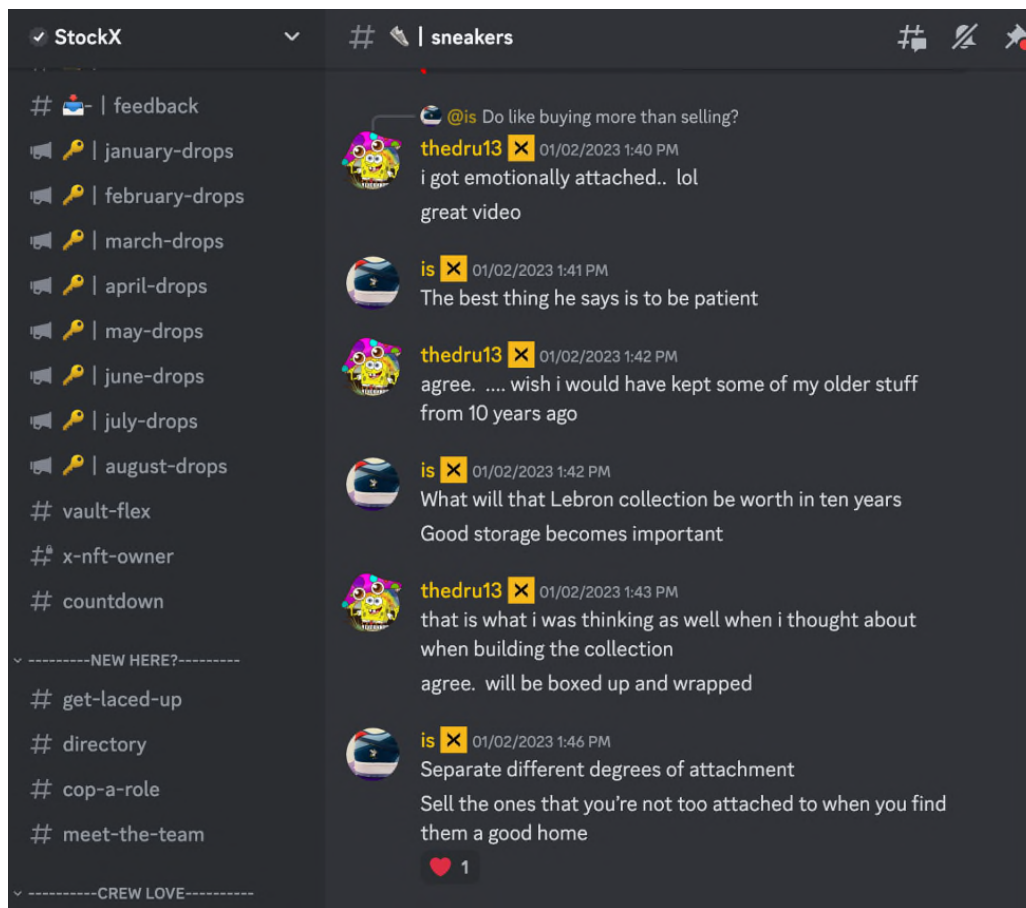


Figure 33: StockX users discussing attachment to their physical shoes.<sup>134</sup>

- (b) The foregoing aligns with the view that users view the StockX Vault NFTs not as an end unto themselves, but rather as simply a tool for the exchange of the underlying physical shoes. This is in marked contrast to the way that holders of digital brand NFTs often attach true identity value to the NFTs themselves, as holders do with CloneX NFTs.
- (c) In addition, the language surrounding utility is very different between the two sets of NFTs. In the case of RTFKT NFTs, users frequently ask about the specific utility of a certain NFT, express the belief there should be more utility, or ask when new utility for NFTs will be announced. This is standard among digital brand NFTs, which are often constantly expected to increase utility, and live and die on the confidence of their users in their ability to increase utility over time for holders.
- (d) By contrast, the StockX Vault NFT holders' discussion is predominantly not focused on utility, but rather on new product releases, prices, and potential trading opportunities. In particular, the StockX Discord certainly features a significant amount of discussion on the current and future value of the Vault NFTs, but that discussion centers almost entirely on whether the Vault NFTs can be sold later for a profit, and if they are overvalued in comparison to the underlying physical assets (see Figure 34).

<sup>134</sup>StockX Discord post from the #sneakers channel, 2 Jan 2023.



Figure 34: User SmithBeenTrill discussing how they use the Vault NFTs solely for flipping.<sup>135</sup>

57. The overall lack of additive utility building on the StockX Vault NFTs also differentiates them from Nike/RTFKT NFTs.
- (a) Nike/RTFKT has built a massive product ecosystem centered around the CloneX and other RTFKT NFTs, and holders frequently receive valuable NFTs and other products simply for holding NFTs in the Nike/RTFKT ecosystem—for illustration, see Figure 35.

<sup>135</sup>StockX Discord post from the #nft-chatter channel, 1 Apr 2023.

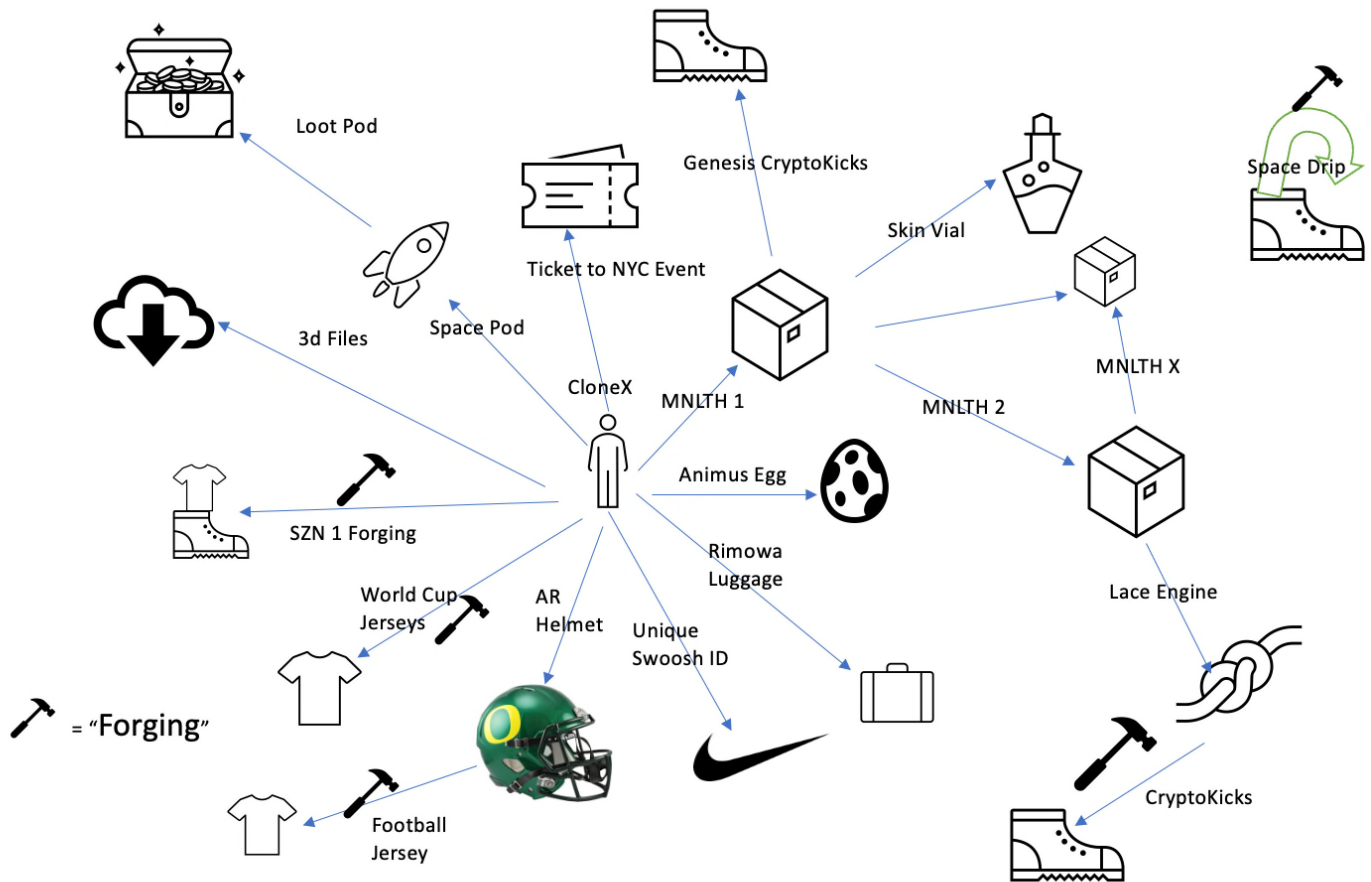


Figure 35: A graphical representation of the utility offered in the RTFKT community, which is centered around the CloneX NFTs.

- (b) By contrast, the StockX Vault NFT series was not, in general, a source of rewards (Figure 36). As described above, StockX briefly experimented with coupons and giveaways for Vault NFT holders, but stopped these rewards soon after. (And again, as noted above, similar rewards were available simply for using the StockX platform.)

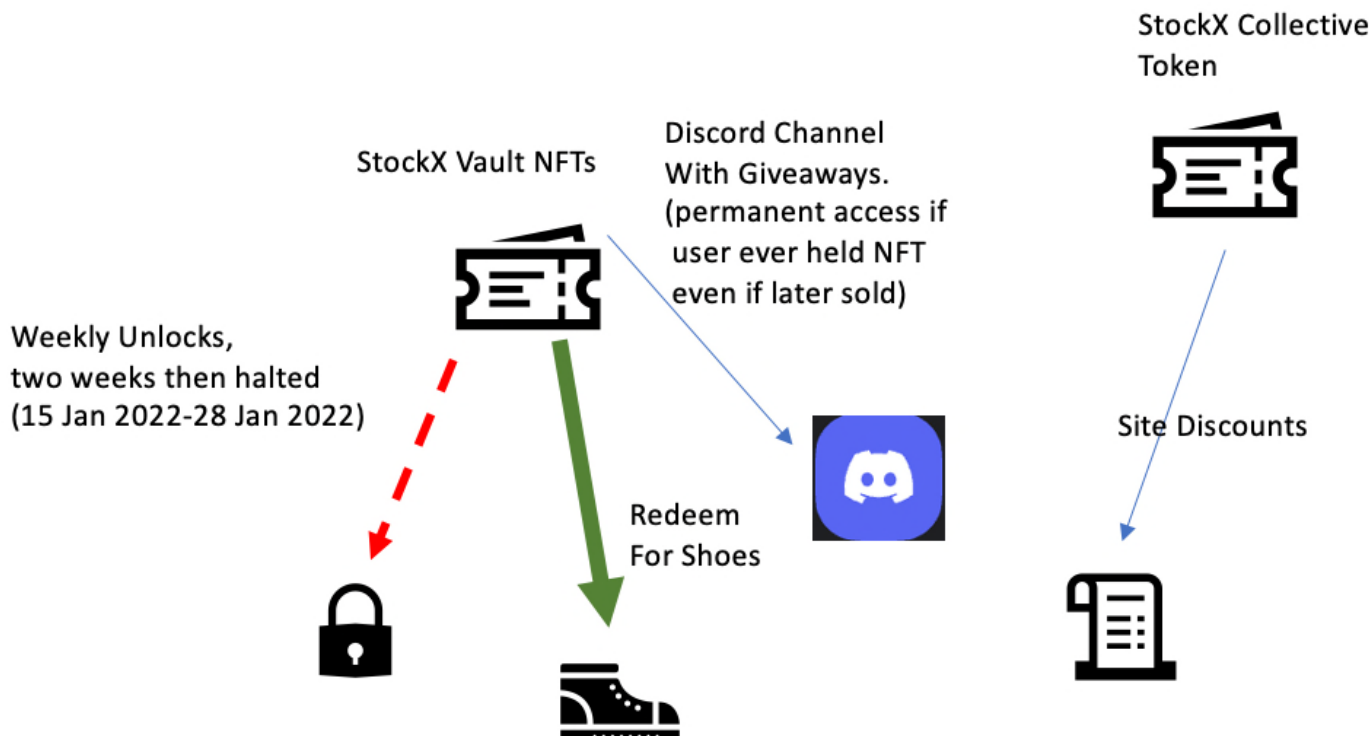


Figure 36: A graphical representation of the utility offered in association with the StockX NFTs.

- (c) Furthermore, even if some purchasers of StockX Vault NFTs may have expected to get advance access to future StockX NFTs, they were told by official StockX online moderators that these NFTs would not work that way (Figure 37).

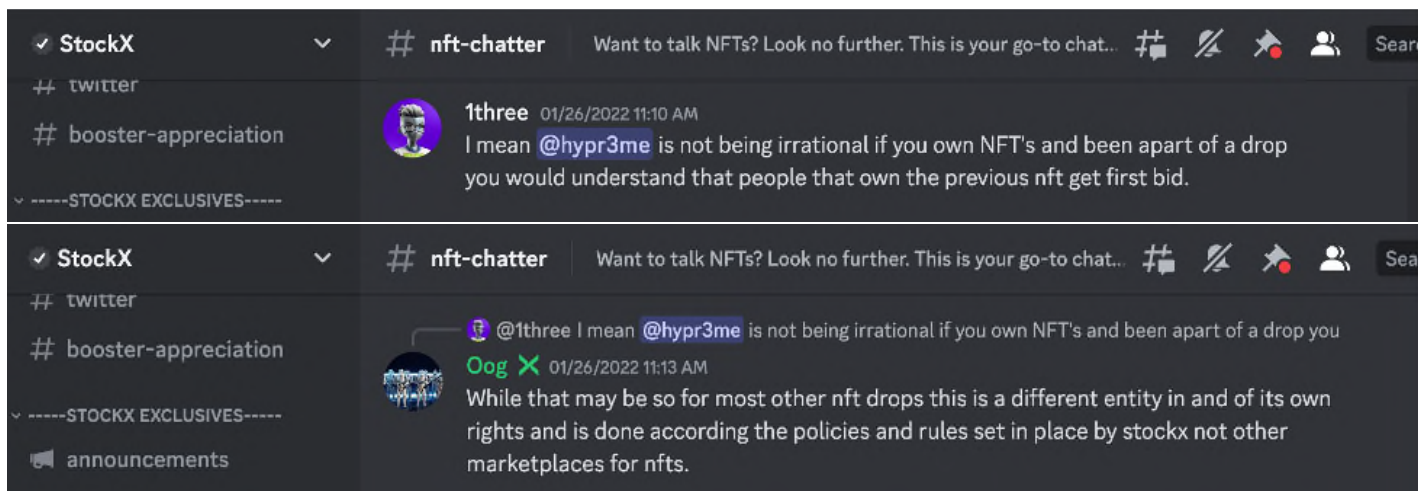


Figure 37: A conversation between a user and moderator in a StockX NFT Discord channel about future NFTs for current holders.<sup>137</sup>

<sup>137</sup>StockX Discord posts from the #nft-chatter channel, 26 Jan 2022.

- (d) This is not the behavior of digital brand NFT collections, which seek to reward early holders and create incentives for individuals to become holders such that they too may be rewarded in the future. StockX's behavior is more akin to simply selling the underlying good—as it otherwise would on its web platform—and using the NFT as a tool to sell the good, rather than building a following around the NFT collection. This is in contrast to Nike/RTFKT, which have an expanding digital brand ecosystem and community centered around their NFTs.

Dated: May 5, 2023

A handwritten signature in black ink, appearing to read "Scott Kominers", with a stylized flourish at the end.

Scott Duke Kominers

# Appendixes

## 1 Source Code Used to Generate Figure 28

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```

import pandas as pd
import matplotlib.pyplot as plt
import numpy as np

# Prompt the user for the NFT file name and provide a warning about the file location
print("Warning: The Excel files should be in the same directory as this script.")
nft_file_name = input("Enter the NFT file name (including the extension): ")

# Read the NFT Excel file
nft_file_path = nft_file_name
nft_df = pd.read_excel(nft_file_path, engine='openpyxl')

# Prompt the user for the physical file name
physical_file_name = input("Enter the physical file name (including the extension): ")

# Read the physical Excel file
physical_file_path = physical_file_name
physical_df = pd.read_excel(physical_file_path, engine='openpyxl')

# Convert column 'created_at_est' in physical_df to datetime
physical_df['created_at_est'] = pd.to_datetime(physical_df['created_at_est'], format='%m/%d/%Y %I:%M:%S %p')

# Prompt the user for a cutoff date
cutoff_date = input('Enter the cutoff date in YYYY-MM-DD format: ')
cutoff_date = pd.Timestamp(cutoff_date)

# Prompt the user for the product to filter
products = [
    'chunky-dunky-vault-nft',
    'aj4-retro-white-oreo-vault-nft',
    'kaws-sacai-blazer-low-blue-vault-nft',
    'jordan-3-retro-a-ma-maniere-vault-nft',
    'air-vapormax-cactus-plant-flea-market-vault-nft',
    'retro-black-and-white-dunk-vault-nft',
    'dunk-low-off-white-lot-50-vault-nft',
    'aj1-retro-high-og-patent-bred-vault-nft',
]

for i, product in enumerate(products, start=1):
    print(f'{i}: {product}')

product_index = int(input('Enter the number (1-8) for the product you want to filter: '))
selected_product = products[product_index - 1]

# Product name mapping
product_name_mapping = {
    'aj1-retro-high-og-patent-bred-vault-nft': 'Air-Jordan-1-Retro-High-OG-Bred-Patent',
    'retro-black-and-white-dunk-vault-nft': 'Nike-Dunk-Low-Retro-White-Black-2021',
    'aj4-retro-white-oreo-vault-nft': 'Air-Jordan-4-Retro-White-Oreo-2021',
    'kaws-sacai-blazer-low-blue-vault-nft': 'Nike-Blazer-Low-sacai-KAWS-Blue',
    'jordan-3-retro-a-ma-maniere-vault-nft': 'Air-Jordan-3-Retro-A-Ma-Maniere-W',
    'dunk-low-off-white-lot-50-vault-nft': 'Nike-Dunk-Low-Off-White-Lot-50',
    'air-vapormax-cactus-plant-flea-market-vault-nft': 'Nike-Air-VaporMax-2019-CPFM',
    'chunky-dunky-vault-nft': 'Nike-SB-Dunk-Low-Ben-Jerrys-Chunky-Dunky'
}

# Map the selected product name to the corresponding name in the physical file
mapped_product_name = product_name_mapping[selected_product]

# Per Counsel, StockX had a technical issue where they failed to sell out and thus got rid of the rest of their
# supply by filling open asks. Because of the obvious warping of economic conclusions that can be drawn given that,
# we begin our analysis only after the last sale by StockX has happened.
# Find the line after the last Yes for the respective product
last_yes_row = nft_df[(nft_df['product'] == selected_product) & (nft_df['Seller StockX?'] == 'Yes')].index.max()
if pd.isna(last_yes_row):
    start_row = 0
else:
    start_row = last_yes_row + 1

# Filter the data based on the given conditions
filtered_df = nft_df[(nft_df['product'] == selected_product) & (nft_df['Seller StockX?'] == 'No') & (nft_df.index > last_yes_row) & (nft_df['created_at_est'] <= cutoff_date)]

# Create a scatterplot
plt.scatter(filtered_df['created_at_est'], filtered_df['gmw'])
plt.xlabel('created_at_est')
plt.ylabel('gmw')
plt.title(f'Scatterplot of created_at_est vs gmw for {selected_product} (up to {cutoff_date.strftime("%Y-%m-%d")})')

# Function to find the value in column B of physical_df that corresponds to the time in column A
# that is closest to x but prior to x and for which the value in column C of physical_df matches the selected product
def find_prior_value(x, df, product):
    prior_rows = df[(df['created_at_est'] <= x) & (df['short_description'] == product)]
    if prior_rows.empty:
        return np.nan
    else:
        return prior_rows.iloc[-1]['gmw']

# Make a copy of filtered_df to avoid the warning
filtered_df_copy = filtered_df.copy()

# Create a red line based on the physical Excel file
filtered_df_copy['red_line'] = filtered_df_copy['created_at_est'].apply(find_prior_value, df=physical_df, product=mapped_product_name)

# Find the last date for the selected product in the second Excel sheet
last_date_physical_df = physical_df[(physical_df['short_description'] == mapped_product_name)]['created_at_est'].max()

# Create the dataframe for the red line.
solid_line_df = filtered_df_copy[filtered_df_copy['created_at_est'] <= last_date_physical_df]

# Plot the red line
plt.plot(solid_line_df['created_at_est'], solid_line_df['red_line'], color='red', label='Red line')

# Mapping product names to their prettier names
product_pretty_names = {
    'kaws-sacai-blazer-low-blue-vault-nft': 'KAWS Sacai Nike Blazer Low Blue',
    'aj4-retro-white-oreo-vault-nft': 'Air Jordan 4 Retro White Oreo',
    'retro-black-and-white-dunk-vault-nft': 'Nike Dunk Low Retro White Black',
    'chunky-dunky-vault-nft': 'Nike SB Dunk Low Ben & Jerry's Chunky Dunky',
    'jordan-3-retro-a-ma-maniere-vault-nft': 'Women's Exclusive Air Jordan 3 Retro A Ma Manière',
}

```

```
'dunk-low-off-white-lot-50-vault-nft': 'Nike Dunk Low Off-White Lot 50',
'air-vapormax-cactus-plant-flea-market-vault-nft': 'Nike Air VaporMax 2019 Cactus Plant Flea Market',
'aj1-retro-high-og-patent-bred-vault-nft': 'Jordan 1 Retro High OG Patent Bred'
}

plt.xlabel('Date')
plt.ylabel('Sale Price in Dollars')
plt.title(f'Sale Price in Dollars Over Time for {product_pretty_names[selected_product]} Vault NFT \n -- Vault NFT '
         f'Compared With Physical Shoe')
plt.xticks(rotation=45)

# Show the scatterplot
plt.show()
```

## **2 Kominers's CV**

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## HARVARD | BUSINESS | SCHOOL

May 5, 2023

### Scott Duke Kominers

Rock Center 219  
Harvard Business School  
Boston, MA 02163  
(301) 529-4162  
skominers@hbs.edu

### EDUCATION

- 2011      Ph.D., Business Economics, Harvard University, Cambridge, Massachusetts  
Dissertation: "Matching Models of Markets."  
Advisors: Alvin E. Roth (chair), Susan Athey, Drew Fudenberg, John William Hatfield, Andrei Shleifer, and E. Glen Weyl.
- 2010      A.M., Business Economics, Harvard University, Cambridge, Massachusetts
- 2009      A.B., *summa cum laude*, Mathematics, Harvard University, Cambridge, Massachusetts  
Minor: Ethnomusicology.  
Thesis: "Weighted Generating Functions and Configuration Results for Type II Lattices and Codes."  
Advisor: Noam D. Elkies.

### TEACHING EXPERIENCE

#### HARVARD UNIVERSITY

##### Appointments

- 2022 – present    Professor, Entrepreneurial Management Unit
- 2022 – present    Faculty Co-Lead, Crypto, Fintech, and Web3 Lab
- 2017 – present    Faculty Affiliate, Department of Economics
- 2015 – present    Faculty Affiliate, Center of Mathematical Sciences and Applications
- 2020 – present    Faculty Affiliate, Data Science Initiative
- 2017 – 2022      MBA Class of 1960 Associate Professor, Entrepreneurial Management Unit
- 2013 – 2017      Associate, Center for Research on Computation and Society
- 2013 – 2017      Junior Fellow, Society of Fellows
- 2016              Lecturer, Entrepreneurial Management Unit
- 2015              Visiting Lecturer, Department of Economics

## Assignments

2024 – present Building Web3 Businesses (MBA Elective Curriculum), Harvard Business School, Spring  
 2023 – present The Web3 SIP (MBA Short Intensive Program), Harvard Business School, Winter  
 2018 – present Making Markets (MBA Elective Curriculum), Harvard Business School, Spring  
 2017 – present Guest Lecturer: Launching New Ventures/Leading Growing Ventures, Endeavor, Entrepreneurs’ Organization (Executive Education), Harvard Business School, Fall/Spring  
 2015 – present Market Design (Doctoral Course), Harvard University, Fall/Spring  
 2016 The Entrepreneurial Manager (MBA Required Curriculum), Harvard Business School, Spring

## UNIVERSITY OF CHICAGO

### Appointments

2011 – 2013 Saieh Family Fellow in Economics, Becker Friedman Institute  
 2011 – 2013 Instructor, Department of Economics

### Assignments

2016 – 2017 Market Design Perspectives on Inequality (Graduate Mini-Course), Chicago Summer School on Socioeconomic Inequality, Summer  
 2012 – 2015 Market Design Approaches to Inequality (Graduate Mini-Course), Chicago Summer School on Socioeconomic Inequality, Summer  
 2012 – 2013 Topics in Matching and Market Design (Doctoral Course), Department of Economics, University of Chicago, Spring 2013; Winter 2012  
 2013 Market Design Approaches to Inequality (Graduate Mini-Course), Beijing Summer School on Socioeconomic Inequality, Summer

## AFFILIATIONS

2022 – present Research Partner, a16z crypto  
 2016 – 2022 Columnist, *Bloomberg Opinion*  
 2015 – 2021 Research Economist, National Bureau of Economic Research  
 2018 – 2019 Eminent Research Visitor, University of Melbourne  
 2016 Visiting Fellow, Oxford Martin School  
 2013 – 2016 Research Scientist, Program for Evolutionary Dynamics, Harvard University  
 2014 – 2015 Visiting Researcher, Microsoft Research New England

## WORK EXPERIENCE

2010 Social Science Analyst, Economic Analysis Group, US Department of Justice, Washington, DC  
 2007 – 2009 Research Assistant to Susan Athey, Edward L. Glaeser, William Kerr, and Andrei Shleifer, Harvard University, Cambridge, MA

2007 Operations Research Engineering Intern, Google, Mountain View, CA

## GRANTS AND FELLOWSHIPS

2021 – present Sloan Foundation Grant to Support Mathematical Sciences Research Institute [MSRI] Programs on “Mathematics and Computer Science of Market and Mechanism Design” and “Algorithmic Fairness” (\$600,000; with Hélène Barcelo, Alaina Moore, and the rest of the MSRI Team)

2019 – present Washington Center for Equitable Growth Grant: “Market Design Responses to Inequality” (\$29,400; with Mohammad Akbarpour, Piotr Dworczak, and Ravi Jagadeesan)

2015 – 2021 NSF Social and Economic Sciences [SES] Grant: “Preferences in Matching Market Design” (\$220,761)

2015 – 2021 NSF Science of Science and Innovation Policy [SciSIP] Grant: “Assessing the Impact of Non-Practicing Entities on U.S. Innovation” (\$385,502; with Lauren Cohen and Umit G. Gurun)

2019 – 2020 Sloan Foundation Conference Grant: “Conference on Big Data” (\$20,000; with Shing-Tung Yau, Richard Freeman, Jun Liu, Nikhil Naik, and Horng-Tzer Yau)

2018 – 2019 University of Melbourne Eminent Research Scholar Grant

2017 Sloan Foundation Conference Grant: “Conference on Big Data” (\$20,000; with Shing-Tung Yau, Richard Freeman, Jun Liu, Nikhil Naik, and Horng-Tzer Yau)

2016 – 2017 Star Family Challenge for Promising Scientific Research Grant: “Computer Vision-Automated Surveys for Urban Science and Economic Development” (\$97,000; with Edward L. Glaeser, Rema Hanna, Benjamin Olken, and Nikhil Naik)

2016 – 2017 Radcliffe Exploratory Seminar Grant: “Predictive Cities: Leveraging New Data and Methods to Improve Urban Quality of Life” (~\$18,000; with Edward L. Glaeser, Michael Luca, and Mitchell B. Weiss).

2016 – 2017 Sloan Foundation Conference Grant: “Conference on Big Data” (\$20,000; with Shing-Tung Yau, Richard Freeman, Jun Liu, Christopher Rogan, and Horng-Tzer Yau)

2016 Oxford Martin School Visiting Fellowship

2015 – 2016 International Growth Centre [IGC] Small Projects Grant (£6,900; with Edward L. Glaeser, Rema Hanna, Benjamin Olken, and Nikhil Naik)

2012 – 2016 NSF Interface between Computer Science and Economics & Social Sciences [ICES] Grant: “Understanding the Roles of Intermediaries in Matching Markets” (\$398,927; with Eric Budish, Ali Hortaçsu, and Nicole Immorlica).

2014 – 2015 William F. Milton Fund Grant (\$39,994)

2015 Econometric Society Travel Grant

2011 – 2014 AMS–Simons Travel Grant

2012 – 2013 Human Capital and Economic Opportunity/Institute for New Economic Thinking Research Grant (with Jay Garlapati)

2009 – 2011 NSF Graduate Research Fellowship

2010 – 2011 Terence M. Considine Fellowship in Law and Economics.

2010 – 2011 Yahoo! Key Scientific Challenges Program Fellowship

2009 – 2011 Harvard Real Estate Academic Initiative Faculty Grant (with E. Glen Weyl)  
 2010 Harvard Institute for Quantitative Social Science Travel Grant  
 2010 Danielan Fund Research and Travel Grant  
 2009 National Defense Science and Engineering Graduate Fellowship (declined)  
 2008 Harvard Institute for Quantitative Social Science Summer Scholars Program Fellowship  
 2008 Harvard College Program for Research in Science and Engineering Fellowship  
 2008 Harvard Mathematics Department Highbridge Fellowship  
 2006 Harvard College Program for Research in Science and Engineering Fellowship  
 2004 Center for Excellence in Education Research Science Institute Summer Scholarship

## AWARDS AND HONORS

2022 Best *Management Science* Paper in Finance Award (with Lauren Cohen and Umit G. Gurun)  
 2018 Best *Economic Inquiry* Article Award (with Edward L. Glaeser, Michael Luca, and Nikhil Naik)  
 2018 Webby Award (“Best Use of Machine Learning” category; with Nikhil Naik, Ramesh Raskar, Edward L. Glaeser, and César A. Hidalgo)  
 2016 Star Family Prize for Excellence in Advising  
 2016 Derek Bok Center Certificate of Distinction in Teaching  
 2015 Kavli Frontiers of Science Fellow  
 2015 Case Centre Award (“Knowledge, Information and Communication Systems Management” category; with Benjamin Edelman)  
 2013 Nominee, John R. Marquand Award for Exceptional Advising and Counseling  
 2013 Center for Excellence in Education Alumni Award for Outstanding Achievement in STEM and Business  
 2011 Third Place, Romanian Institute of Science and Technology “Best PhD Thesis in Computational Game Theory” Competition  
 2010 Yahoo! Key Scientific Challenges Program Selectee  
 2010 St. Mark’s Institute of Mathematics Great Math Challenge Award (with Paul M. Kominers)  
 2010 AMS-MAA-SIAM Frank and Brennie Morgan Prize for Outstanding Research in Mathematics by an Undergraduate Student  
 2009 George Caspar Homans Prize  
 2009 Thomas Temple Hoopes Prize  
 2009 Phi Beta Kappa  
 2008 First Place, Robert Fletcher Rogers Prize  
 2007 – 2008 John Harvard Scholarship  
 2005 First Place, American Mathematical Society Karl Menger Prize  
 2005 Second Place, Mathematics Category, Intel International Science and Engineering Fair

2004

California Institute of Technology Signature Award in Mathematics

**PUBLICATIONS****Full-Length Refereed Journal Articles**

Mohammad Akbarpour, Scott Duke Kominers, Shengwu Li, and Paul R. Milgrom. “Investment Incentives in Near-Optimal Mechanisms.” Accepted conditional upon revision, *Econometrica*.

David Delacrétaz, Scott Duke Kominers, and Alexander Teytelboym. “Matching Mechanisms for Refugee Resettlement.” Accepted conditional upon revision, *American Economic Review*.

Mohammad Akbarpour ® Piotr Dworzak ® Scott Duke Kominers. “Redistributive Allocation Mechanisms.” Forthcoming, *Journal of Political Economy*. (The “®” symbol indicates that the authors’ names are in certified random order.)

Mohammad Akbarpour ® Eric Budish ® Piotr Dworzak ® Scott Duke Kominers. “An Economic Framework for Vaccine Allocation.” Forthcoming, *Quarterly Journal of Economics*. (The “®” symbol indicates that the authors’ names are in certified random order.)

Piotr Dworzak ® Scott Duke Kominers ® Mohammad Akbarpour. “Redistribution through Markets.” *Econometrica*, 89:4 (2021), pp. 1665–1698. (The “®” symbol indicates that the authors’ names are in certified random order.)

John William Hatfield, Scott Duke Kominers, and Alexander Westkamp. “Stability, Strategy-Proofness, and Cumulative Offer Mechanisms.” *Review of Economic Studies*, 88:3 (2021), 1457–1502.

Juan Camilo Castillo, Amrita Ahuja, Susan Athey, Arthur Baker, Eric Budish, Tasneem Chipty, Rachel Glennerster, Scott Duke Kominers, Michael Kremer, Jean Nahrae Lee, Canice Prendergast, Christopher Snyder, Alex Tabarrok, Brandon Tan, and Witold Więcek. “Market Design to Accelerate COVID-19 Vaccine Supply.” *Science*, 371:6534 (2021), 1107–1109.

John William Hatfield, Scott Duke Kominers, Alexandru Nichifor, Michael Ostrovsky, and Alexander Westkamp. “Chain Stability in Trading Networks.” *Theoretical Economics*, 16:1 (2021), 197–234.

Arnaud Dupuy, Alfred Galichon, Sonia Jaffe, and Scott Duke Kominers. “Taxation in Matching Markets.” *International Economic Review*, 61:4 (2020), 1591–1634.

John William Hatfield, Scott Duke Kominers, Richard Lowery, and Jordan M. Barry. “Collusion in Markets with Syndication.” *Journal of Political Economy*, 128:10 (2020), 3779–3819.

Alfred Galichon, Scott Duke Kominers, and Simon Weber. “Costly Concessions: An Empirical Framework for Matching with Imperfectly Transferable Utility.” *Journal of Political Economy*, 127:6 (2019), 2875–2925.

Lauren Cohen, Umit G. Gurun, and Scott Duke Kominers. “Patent Trolls: Evidence from Targeted Firms.” *Management Science*, 65:12 (2019), 5461–5486.

John William Hatfield, Scott Duke Kominers, Alexandru Nichifor, Michael Ostrovsky, and Alexander Westkamp. “Full Substitutability.” *Theoretical Economics*, 14:4 (2019), 1535–1590.

- Umut Dur, Scott Duke Kominers, Parag A. Pathak, and Tayfun Sönmez. “Reserve Design: Unintended Consequences and the Demise of Boston’s Walk Zones.” *Journal of Political Economy*, 126:6 (2018), 2457–2479.
- Gary S. Becker, Scott Duke Kominers, Kevin M. Murphy, and Jörg L. Spenkuch. “A Theory of Intergenerational Mobility.” *Journal of Political Economy*, 126:S1 (2018), S7–S25.
- Ravi Jagadeesan, Scott Duke Kominers, and Ross Rheingans-Yoo. “Strategy-Proofness of Worker-Optimal Matching with Continuously Transferable Utility.” *Games and Economic Behavior*, 108 (2018), 287–294.
- Nikhil Naik, Scott Duke Kominers, Ramesh Raskar, Edward L. Glaeser, and César A. Hidalgo. “Computer Vision Uncovers Predictors of Physical Urban Change.” *Proceedings of the National Academy of Sciences*, 114:29 (2017), 7571–7576.
- John William Hatfield and Scott Duke Kominers. “Contract Design and Stability in Many-to-Many Matching.” *Games and Economic Behavior*, 101 (2017), 78–97.
- Scott Duke Kominers and Tayfun Sönmez. “Matching with Slot-Specific Priorities: Theory.” *Theoretical Economics*, 11:2 (2016), 683–710.
- Lauren Cohen, Umit G. Gurun, and Scott Duke Kominers. “The Growing Problem of Patent Trolling.” *Science*, 352:6285 (2016), 521–522.
- John William Hatfield and Scott Duke Kominers. “Multilateral Matching.” *Journal of Economic Theory*, 156 (2015), 175–206. (Corrigendum by Keisuke Bando, Toshiyuki Hirai, John William Hatfield, and Scott Duke Kominers. *Journal of Economic Theory*, 184 (2019), Art. 104933.)
- William R. Kerr and Scott Duke Kominers. “Agglomerative Forces and Cluster Shapes.” *Review of Economics and Statistics*, 97:4 (2015), 877–899.
- Drew Fudenberg, Yuhta Ishii, and Scott Duke Kominers. “Delayed-Response Strategies in Repeated Games with Observation Lags.” *Journal of Economic Theory*, 150 (2014), 487–514.
- John William Hatfield, Scott Duke Kominers, Alexandru Nichifor, Michael Ostrovsky, and Alexander Westkamp. “Stability and Competitive Equilibrium in Trading Networks.” *Journal of Political Economy*, 121:5 (2013), 966–1001.
- Scott Duke Kominers. “On the Correspondence of Contracts to Salaries in (Many-to-Many) Matching.” *Games and Economic Behavior*, 75:2 (2012), 984–989.
- John William Hatfield, Nicole Immorlica, and Scott Duke Kominers. “Testing Substitutability.” *Games and Economic Behavior*, 75:2 (2012), 639–645.
- John William Hatfield and Scott Duke Kominers. “Matching in Networks with Bilateral Contracts.” *American Economic Journal: Microeconomics*, 4:1 (2012), 176–208. (Corrigendum by John William Hatfield, Ravi Jagadeesan, and Scott Duke Kominers. *American Economic Journal: Microeconomics*, 12:3 (2020), 277–285.)

Scott Duke Kominers. “Matching with Preferences over Colleagues Solves Classical Matching.” *Games and Economic Behavior*, 68:2 (2010), 773–780.

### Short Refereed Journal Articles

Jiafeng Chen and Scott Duke Kominers. “Auctioneers Sometimes Prefer Entry Fees to Extra Bidders.” *International Journal of Industrial Organization*, 79 (2021), Art. 102737.

David Delacrétaz, Scott Duke Kominers, and Alexandru Nichifor. “Comparative Statics for Size-Dependent Discounts in Matching Markets.” *Journal of Mathematical Economics*, 90 (2020), 127–131.

Ravi Jagadeesan, Scott Duke Kominers, and Ross Rheingans-Yoo. “Lone Wolves in Competitive Equilibria.” *Social Choice and Welfare*, 55:2 (2020), 215–228.

Franklyn Wang, Ravi Jagadeesan, and Scott Duke Kominers. “Optimizing Reserves in School Choice: A Dynamic Programming Approach.” *Operations Research Letters*, 47:5 (2019), 438–446.

Jonah Kallenbach, Robert Kleinberg, and Scott Duke Kominers. “Orienteering for Electioneering.” *Operations Research Letters*, 46:2 (2018), 205–210.

Louis Kaplow and Scott Duke Kominers. “Who Will Vote Quadratically? Voter Turnout and Votes Cast Under Quadratic Voting.” *Public Choice*, 172:1-2 (2017), 125–149.

Benjamin Edelman, Sonia Jaffe, and Scott Duke Kominers. “To Groupon or Not to Groupon: The Profitability of Deep Discounts.” *Marketing Letters*, 27:1 (2016), 39–53.

Abel N. Kho, John P. Cashy, Kathryn Jackson, Adam R. Pah, Satyender Goel, Jörn Boehnke, John Eric Humphries, Scott Duke Kominers, Bala N. Hota, Shannon A. Sims, Brad A. Malin, Dustin D. French, Theresa L. Walunas, David O. Meltzer, Erin O. Kaleba, Roderick C. Jones, and William L. Galanter. “Design and Implementation of a Privacy Preserving Electronic Health Record Linkage Tool in Chicago.” *Journal of the American Medical Informatics Association*, 22:5 (2015), 1072–1080.

Matthew Cary, Aparna Das, Benjamin Edelman, Ioannis Giotis, Kurtis Heimerl, Anna Karlin, Scott Duke Kominers, Claire Mathieu, and Michael Schwarz. “Convergence of Position Auctions under Myopic Best-Response Dynamics.” *ACM Transactions on Economics and Computation*, 2:3 (2014), 1–20.

John William Hatfield and Scott Duke Kominers. “Vacancies in Supply Chain Networks.” *Economics Letters*, 119:3 (2013), 354–357.

Sonia Jaffe and Scott Duke Kominers. “Discrete Choice Cannot Generate Demand That Is Additively Separable in Own Price.” *Economics Letters*, 116:1 (2012), 129–132.

Yuichiro Kamada and Scott Duke Kominers. “Information Can Wreck Cooperation: A Counterpoint to Kandori (1992).” *Economics Letters*, 107:2 (2010), 112–114.

### Refereed Mathematics Articles

Scott Duke Kominers. “Oh’s 8-universality Criterion is Unique.” *Kyungpook Mathematical Journal*, 61:3 (2021), 455–459.

- Daniel M. Kane and Scott Duke Kominers. “Prisoners, Rooms, and Light Switches.” *Electronic Journal of Combinatorics*, 28:1 (2021), P1.27.
- Noam D. Elkies and Scott Duke Kominers. “Configurations of Extremal Type II Codes via Harmonic Weight Enumerators.” *Journal de Théorie des Nombres de Bordeaux*, 31:3 (2019), 679–688.
- Daniel M. Kane and Scott Duke Kominers. “Asymptotic Improvements of Lower Bounds for the Least Common Multiples of Arithmetic Progressions.” *Canadian Mathematical Bulletin*, 5:3 (2014), 551–561.
- Noam D. Elkies, Daniel M. Kane, and Scott Duke Kominers. “Minimal  $S$ -universality Criteria May Vary in Size.” *Journal de Théorie des Nombres de Bordeaux*, 25:3 (2013), 557–563.
- Noam D. Elkies and Scott Duke Kominers. “Weighted Generating Functions for Type II Lattices and Codes.” In *Quadratic and Higher Degree Forms*, edited by Krishnaswami Alladi, Manjul Bhargava, David Savitt, and Pham Huu Tiep, Springer, (2013), 63–108.
- Timothy G. Abbott, Zachary Abel, David Charlton, Erik D. Demaine, Martin L. Demaine, and Scott Duke Kominers. “Hinged Dissections Exist.” *Discrete & Computational Geometry*, 47:1 (2012), 150–186.
- Zachary Abel, Brad Ballinger, Prosenjit Bose, Sébastien Collette, Vida Dujmović, Ferran Hurtado, Scott Duke Kominers, Stefan Langerman, Attila Pór, and David R. Wood. “Every Large Point Set Contains Many Collinear Points or an Empty Pentagon.” *Graphs and Combinatorics*, 27:1 (2011), 47–60.
- Daniel Litt, Zachary Abel, and Scott Duke Kominers. “A Categorical Construction of Ultrafilters.” *Rocky Mountain Journal of Mathematics*, 40:5 (2010), 1611–1617.
- Paul Myer Kominers and Scott Duke Kominers. “A Constant Bound for the Periods of Parallel Chip-Firing Games with Many Chips.” *Archiv der Mathematik*, 95:1 (2010), 9–13.
- Sherry Gong and Scott Duke Kominers. “On Congruence Conditions for Primality.” *INTEGERS: The Electronic Journal of Combinatorial Number Theory*, 10:3 (2010), 313–317.
- Scott Duke Kominers. “Irrational Roots Revisited.” *The Mathematical Gazette*, 94:530 (2010), 303–304.
- Noam D. Elkies and Scott Duke Kominers. “On the Classification of Type II Codes of Length 24.” *SIAM Journal on Discrete Mathematics*, 23:4 (2010), 2173–2177.
- Shaofang Hong and Scott Duke Kominers. “Further Improvements of Lower Bounds for the Least Common Multiples of Arithmetic Progressions.” *Proceedings of the American Mathematical Society*, 138:3 (2010), 809–813.
- Paul Myer Kominers and Scott Duke Kominers. “Improved Bounds on the Sizes of  $S \cdot P$  Numbers.” *The Mathematical Gazette*, 94:529 (2010), 127–129.
- Zachary Abel, Nadia Benbernou, Mirela Damian, Erik D. Demaine, Martin L. Demaine, Robin Flatland, Scott Duke Kominers, and Robert Schweller. “Shape Replication through Self-Assembly and RNase Enzymes.” In *Proceedings of the Twenty-First Annual ACM-SIAM Symposium on Discrete Algorithms*, (2010), 1045–1064.

Noam D. Elkies and Scott Duke Kominers. “Refined Configuration Results for Extremal Type II Lattices of Ranks 40 and 80.” *Proceedings of the American Mathematical Society*, 138:1 (2010), 105–108.

Scott Duke Kominers. “Finding Matrices that Satisfy Functional Equations.” *College Mathematics Journal*, 40:4 (2009), 289–292.

Scott Duke Kominers. “Configurations of Extremal Even Unimodular Lattices.” *International Journal of Number Theory*, 5:3 (2009), 457–464.

Scott Duke Kominers. “On Universal Binary Hermitian Forms.” *INTEGERS: The Electronic Journal of Combinatorial Number Theory*, 9:1 (2009), 9–15.

Scott Duke Kominers. “A Correspondence Note on Myerson’s ‘Irrationality via Well-ordering’.” *Gazette of the Australian Mathematical Society*, 36:1 (2009), 53.

Scott Duke Kominers and Zachary Abel. “Configurations of Rank- $40r$  Extremal Even Unimodular Lattices ( $r = 1, 2, 3$ ).” *Journal de Théorie des Nombres de Bordeaux*, 20:2 (2008), 365–371.

Scott Duke Kominers. “Uniqueness of the 2-Universality Criterion.” *Note di Matematica*, 28:2 (2008), 203–206.

#### **Other Refereed Articles**

Minh-Phuong Huynh-Le, Amanda J. Walker, Scott Duke Kominers, Ido Paz-Priel, Moody D. Wharam, and Stephanie A. Terezakis. “Patterns of Failure After Involved Field Radiation Therapy for Pediatric and Young Adult Hodgkin Lymphoma.” *Pediatric Blood & Cancer*, 61:7 (2014), 1210–1214.

Scott Duke Kominers. “Leonard Bernstein’s Doodles: Reading Outside the Lines at the Library of Congress.” *Journal of the Society for American Music*, 3:1 (2009), 26–33. (As an appendix to “Leonard Bernstein’s Jewish Boston: Cross-Disciplinary Research in the Classroom” by Carol J. Oja and Kay Kaufman Shelemay.)

#### **Other Economics and Business Research Articles**

Scott Duke Kominers and The 1337 Skulls Sers. “A New NFT Launch Strategy: The Wave Mint.” *al6z crypto*, (April 6, 2023).

Jordan M. Barry, John William Hatfield, Scott Duke Kominers, and Richard Lowery. “Not from Concentrate: Collusion in Collaborative Industries.” *Iowa Law Review* 108:3 (2023), 1089–1148.

Jad Esber and Scott Duke Kominers. “Progressive Decentralization: A High-level Framework.” *al6z crypto*, (January 12, 2023).

Bernstein, Shai, and Scott Duke Kominers. “Why Decentralized Crypto Platforms Are Weathering the Crash.” *Harvard Business Review [Digital Article]*, (December 7, 2022).

Scott Duke Kominers and Alex Tabarrok. “Vaccines and the Covid-19 Pandemic: Lessons from Failure and Success.” *Oxford Review of Economic Policy*, 38:4 (2022), 719–741.

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- Flashrekt and Scott Duke Kominers. “Why NFT Creators Are Going cc0.” *a16z crypto*, (August 3, 2022).
- Pranav Garimidi, Scott Duke Kominers, and Tim Roughgarden. “DAO governance attacks, and how to avoid them.” *a16z crypto*, (July 28, 2022).
- Scott Duke Kominers. “Metaverse Land: What Makes Digital Real Estate Valuable.” *a16z crypto*, (June 2, 2022).
- Jad Esber and Scott Duke Kominers. “Why Build in Web3.” *Harvard Business Review Digital Articles*, (May 16, 2022).
- Christian Catalini and Scott Duke Kominers. “Can WEB3 Bring Back Competition to Digital Platforms?” *CPI TechREG Chronicle*, (February 23, 2022).
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- Scott Duke Kominers and Jad Esber. “With Decentralized Identity, Your Reputation Travels with You Across Cyberspace.” *Future* (November 18, 2021).
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- Li Jin, Scott Duke Kominers, and Lila Shroff. “A Labor Movement for the Platform Economy.” *Harvard Business Review [Digital Article]*, (September 24, 2021).
- Jad Esber and Scott Duke Kominers. “A Novel Framework for Reputation-Based Systems.” *Future* (September 30, 2021).
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- Christian Catalini, Ravi Jagadeesan, and Scott Duke Kominers. “Bitcoin and Beyond.” *Project Syndicate*, (April 23, 2021).

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### **Refereed Conference Articles**

Duncan Rheingans-Yoo, Hongyao Ma, Scott Duke Kominers, and David C. Parkes. “Ridesharing with Driver Location Preferences.” In *Proceedings of the Twenty-Eighth International Joint Conference on Artificial Intelligence*, (2019), 557–564.

Taylor Lundy, Alexander Wei, Hu Fu, Scott Duke Kominers, and Kevin Leyton-Brown. “Allocation for Social Good: Auditing Mechanisms for Utility Maximization.” In *Proceedings of the 2019 ACM Conference on Economics and Computation*, (2019), 785–803.

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### Expository Articles, Notes, and Reviews (selected)

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John William Hatfield, Ravi Jagadeesan, Scott Duke Kominers, Alexandru Nichifor, Michael Ostrovsky, Alexander Teytelboym, and Alexander Westkamp. “Generalized Matching: Contracts and Networks.” In *Online and Matching-Based Market Design*, edited by Federico Echenique, Nicole Immorlica, and Vijay V. Vazirani, Cambridge University Press, (forthcoming).

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### Books and Edited Collections

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## Teaching Materials

Jeffrey J. Bussgang, Scott Duke Kominers, and Amy Klopfenstein. "SuperRare: Turning an NFT Marketplace into a DAO." Harvard Business School Case 823-027, (August 2022), [20p].

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Shai Bernstein, Scott Duke Kominers, and George Gonzalez. "LooksRare: The Decentralized, Tokenized, NFT Marketplace." Harvard Business School Teaching Note 823-046, (2022), [22p].

Scott Duke Kominers, Das Narayandas, and Kerry Herman. "Bored Ape Yacht Club: Navigating the NFT World." Harvard Business School Case 822-065, (2022, rev. 2023), [30p].

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Scott Duke Kominers and Nicole Tempest Keller. "NFX Capital and Moov Technologies." Harvard Business School Case 822-045, (2022), [18p].

Scott Duke Kominers and Alexandru Nichifor. "Birchal: Equity Crowdfunding in Australia." Harvard Business School Case 822-034, (2021), [19p].

Karen G. Mills, Scott Duke Kominers, Christopher Stanton, Andy Wu, George Gonzalez, and Gabriella Elanbeck. "Zoom Video Communications: Building a Culture of Diversity, Equity, & Inclusion During COVID-19." Harvard Business School Case 322-031, (2021), [25p].

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Scott Duke Kominers and Carin-Isabel Knoop. “Klöckner & Co: Steeling for a Digital World.” Harvard Business School Case 820-035, (2020), [20p].

Scott Duke Kominers and George Gonzalez. “Lunchclub: Algorithmic Networking.” Harvard Business School Case 820-051, (2020), [14p].

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Scott Duke Kominers and Allison M. Ciechanover. “GoFundMe: The Giving Layer of the Internet.” Harvard Business School Case 818-108, (2018), [22p].

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Scott Duke Kominers and Alan Lam. “Feeding America (A).” Harvard Business School Case 818-130, (2018), [14p].

Scott Duke Kominers and Alan Lam. “Feeding America (B).” Harvard Business School Supplement 818-131, (2018), [5p].

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Lauren H. Cohen, Umit G. Gurun, Scott Duke Kominers, and Sarah Mehta. “When Trolls Attack: Carbonite vs. Oasis Research.” Harvard Business School Case 219-001, (January 2019, rev. May 2019), [23p].

Thomas R. Eisenmann, Scott Duke Kominers, and David Lane. “Cadre.” Harvard Business School Case 818-058, (March 2018, rev. July 2018), [19p].

Rohit Deshpandé, Paul A. Gompers, and Scott Duke Kominers. “Yo-Yo Ma and Silkroad.” Harvard Business School Case 818-110, (2018, rev. 2019), [28p].

Lauren H. Cohen, Umit G. Gurun, Scott Duke Kominers, and George Hou. “Patent Trolling.” Harvard Business School Background Note 218-085, (2018), [15p].

Thomas R. Eisenmann and Scott Duke Kominers. “Making Markets.” Harvard Business School Technical Note 818-096, (January 2018, rev. February 2018), [25p].

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Benjamin Edelman and Scott Duke Kominers. “Online Marketing at Big Skinny.” Harvard Business School Teaching Note 911-034, (2011, rev. 2014), [16p].

## **WORKING PAPERS (SELECTED)**

John William Hatfield, Scott Duke Kominers, and Richard Lowery. “Collusion in Brokered Markets.” Revision requested, *Journal of Finance*.

Louis Kaplow and Scott Duke Kominers. “On the Representativeness of Voter Turnout.” Revision requested, *Journal of Law and Economics*.

Edward L. Glaeser, Andrew Hillis, Hyunjin Kim, Scott Duke Kominers, and Michael Luca. “Decision Authority and the Returns to Algorithms.” Revision requested, *Strategic Management Journal*.

John William Hatfield and Scott Duke Kominers. “A Simple Theory of Vampire Attacks.”

Filip Tokarski ® Scott Duke Kominers ® Mohammad Akbarpour ® Piotr Dworzak. “A Market Design Response to the European Energy Crisis.” (The “®” symbol indicates that the authors’ names are in certified random order.)

Mirac Suzgun, Suproteem Sarkar, Luke Melas-Kyriazi, Scott Duke Kominers, and Stuart Shieber. “The Harvard University Patent Dataset: A Large-Scale, Well-Structured, and Multi-Domain Corpus of Patent Applications.”

Scott Duke Kominers, Parag A. Pathak, Tayfun Sönmez, and M. Utku Ünver. “Paying It Backward and Forward: Expanding Access to Convalescent Plasma Therapy Through Market Design.”

John William Hatfield and Scott Duke Kominers. “Hidden Substitutes.”

John William Hatfield, Fuhito Kojima, and Scott Duke Kominers. “Strategy-Proofness, Investment Efficiency, and Marginal Returns: An Equivalence.”

Sai Srivatsa Ravindranath, Zhe Feng, Shira Li, Jonathan Ma, Scott Duke Kominers, and David C. Parkes. “Deep Learning for Two-Sided Matching.”

Naveen Durvasula, Franklyn H. Wang, and Scott Duke Kominers. “Recommending with Recommendations.”

Christian Catalini, Ravi Jagadeesan, and Scott Duke Kominers. “Markets for Crypto Tokens, and Security under Proof of Stake.”

Yannai A. Gonczarowski, Scott Duke Kominers, and Ran I. Shorrer. “To Infinity and Beyond: Scaling Economic Theories via Logical Compactness.”

Scott Duke Kominers. “Respect for Improvements and Comparative Statics in Matching Markets.”

Scott Duke Kominers, Xiaosheng Mu, and Alexander Peysakhovich. “Paying (for) Attention: The Impact of Information Processing Costs on Bayesian Inference.”

## **PRESENTATIONS**

### **Research Lectures**

“A Simple Theory of Vampire Attacks”

Harvard SEAS Economics and Computer Science Research Seminar (April 15, 2023), “Advances in the Economic Theories for Blockchains and Web3” session, AEA Meetings (January 6, 2022); General Seminar, a16z crypto (December 1, 2022); Entrepreneurial Management Unit Research Lunch, Harvard Business School (November 9, 2022).

“Digital Assets and Market Design”

Round: The Front Page (November 17, 2022); MIT IDE Lunch Seminar Series (April 21, 2022).

“An Economic Framework for Vaccine Allocation”

ACM Conference on Economics and Computation (July 14, 2022); Sixth Marketplace Innovation Workshop (May, 2022); “COVID-19” session, Conference on Equity and Access in Algorithms, Mechanisms, and Optimization (October 7, 2021).

“Redistributive Allocation Mechanisms”

Crypto Research Seminar, a16z crypto (July 7, 2022); Department Seminar, University of Bristol School of Economics (May 25, 2022); Frontiers in Economics 4 Ukraine Seminar, Kyiv School of Economics (May 18, 2022); “Economic Theory” session, Royal Economic Society Conference (April 13, 2022); “New Directions in Mechanism Design” session, AEA Meetings (January 9, 2022); “Mechanism Design and Markets” Session, EEA-ESEM Virtual Congress (August 26, 2021); Marketplace Innovation Workshop (May 25, 2021).

“Developing a Large-Scale, Well-Structured, and Multi-Domain Corpus of Patent Applications”  
Fenrir, LLC Data Science Seminar (August 25, 2021).

“Respect for Improvements and Comparative Statics in Matching Markets”  
Sixth World Congress of the Game Theory Society [GAMES2021] (July 23, 2021); AMS Session on  
“Operations Research, Mathematical Programming, Optimization, Game Theory, Economics, and  
Mathematics in the Social and Behavioral Sciences,” Joint Mathematics Meetings (January 18, 2019).

“Collusion in Brokered Markets”  
Sixth World Congress of the Game Theory Society [GAMES2021] (July 23, 2021).

“Investment Incentives in Near-Optimal Mechanisms”  
22nd ACM Conference on Economics and Computation [EC’21] (July 21, 2021); 47th Annual  
Conference of the European Association for Research in Industrial Economics [EARIE] (August 28,  
2020).

“To Infinity and Beyond: Scaling Economic Theories via Logical Compactness”  
Australasian Meeting of the Econometric Society (July 7, 2021); University of Michigan Economic  
Theory Seminar (April 16, 2021); North Carolina State University Microeconomic Theory Seminar  
(April 14, 2021); Israel Algorithmic Game Theory Seminar (January 19, 2020); Harvard/MIT  
Economic Theory Workshop (November 5, 2020); Harvard Center of Mathematical Sciences and  
Applications Colloquium (February 12, 2020); NSF/NBER/CEME Mathematical Economics  
Conference (October 25, 2019); Stony Brook Workshop on Simplicity and Robustness in Complex  
Markets (July 11, 2019).

“Redistribution through Markets”  
AlixPartners Economics Academic Speaker Series (June 24, 2021); New Zealand Economics  
eSeminar (May 12/13, 2021); University of Tokyo Market Design Center International Workshop in  
Market Design (March 24/25, 2021); Equitable Growth Grantee Conference (December 7, 2020);  
Max Planck Institute for Research on Collective Goods (November 23, 2020); Conference on  
Mechanism and Institution Design (June 12, 2020); TGS Management Company Seminar (May 29,  
2020); Marist College School of Management Research Seminar (May 6, 2020); Inter-Institutional  
Virtual Market Design Seminar (April 20, 2020); California Institute of Technology Economic  
Theory Seminar (April 15, 2020); “Matching under Inequality: Implications for Policy” session, AEA  
Meetings (January 4, 2020); Invited Talk, 30th Stony Brook International Conference on Game  
Theory (July 15, 2019); Third Workshop on Mechanism Design for Social Good [MD4SG] (June 28,  
2019); KU Leuven Economics Seminar (April 23, 2019); Harvard School of Engineering and Applied  
Sciences Widely Applied Mathematics Seminar (April 11, 2019); MIT Media Lab (April 10, 2019);  
University of San Diego Law and Finance Seminar (March 15, 2019); Microeconomics Workshop,  
Center for Research and Education in Program Evaluation [CREPE], University of Tokyo (December  
18, 2018); Invited Talk, Asia-Pacific Industrial Organization Conference (December 15, 2018);  
Harvard University Public Finance Seminar (November 12, 2018); Carnegie Mellon  
University/University of Pittsburgh Microeconomic Theory Seminar (November 8, 2018); Keynote  
Talk, Arne Ryde Conference on “Frontiers of Market Design,” Lund University (September 23,  
2018); University of Melbourne Economic Theory and Experiments Seminar (August 17, 2018);  
Boston College Microeconomics Seminar (May 9, 2018); Berkeley University Economic Theory  
Seminar (April 23, 2018).

“Market Design to Accelerate and Allocate COVID-19 Vaccines”  
CME Group-MSRI Prize Virtual Seminar (December 11, 2020); NBER Market Design Working  
Group Meeting (October 22, 2020).

- “A Three-Part Framework for Entrepreneurial Marketplace Design”  
SEEK Strategy Lunch (December 10, 2020).
- “Markets for Crypto Tokens, and Security under Proof of Stake”  
Università Cattolica Economics Seminar (November 12, 2020).
- “Computer Vision Uncovers Predictors of Physical Urban Change”  
Wolfe Research QES NLP Conference (April 21, 2020); Harvard Center of Mathematical Sciences and Applications Workshop on Foundations of Computational Science (August 30, 2019); Keystone Strategy Seminar (May 10, 2019).
- “Collusion in Markets with Syndication”  
Asia-Pacific Industrial Organization Conference (December 13, 2019); University of Melbourne Economic Theory and Experiments Seminar (July 26, 2019); Stanford Graduate School of Business Economics Seminar (May 30, 2018); Harvard Law, Economics, and Organizations Workshop (November 20, 2017); Michigan State University Economic Theory Seminar (November 17, 2017); Becker Friedman Institute Fellows’ Seminar, University of Chicago (October 12, 2017); Harvard/MIT Economic Theory Workshop (April 27, 2017).
- “Chain Stability in Trading Networks”  
19th ACM Conference on Economics and Computation [EC’18] (June 21, 2018).
- “Hidden Substitutes”  
INFORMS Workshop on Mathematical Optimization in Market Design (June 18, 2018); CIREQ Montreal Microeconomic Theory Conference (November 19, 2016); NBER Market Design Working Group Meeting (October 28, 2016); 16th ACM Conference on Electronic Commerce [EC’15] (June 16, 2015); Yale University Microeconomic Theory Lunch (April 28, 2015).
- “Patent Trolls: Evidence from Targeted Firms”  
Simon Fraser University Economic Theory Seminar (October 4, 2017); Facebook, Inc. Research Seminar (October 27, 2016); Robert F. Lanzillotti Public Policy Research Center and University of Florida Conference on The Economics of Innovation (May 20, 2016); Harvard Center of Mathematical Sciences and Applications Social Science Applications Forum (February 29, 2015); United States Patent and Trademark Office Research Seminar (March 17, 2015); MIT Applied Microeconomics Seminar (March 2, 2015); George Washington University Law School and the United States Patent and Trademark Office “Works in Progress Intellectual Property Colloquium [WIPIP]” (February 7, 2015); “Entrepreneurial Finance” session, AFA Meetings (January 4, 2015); Harvard Law, Economics, and Organizations Workshop (November 24, 2014); University of Chicago Booth School of Business Applied Economics Workshop (November 5, 2014); NBER Summer Institute Workshop on Innovation (July 16, 2014).
- “Strategy-Proofness, Investment Efficiency, and Marginal Returns: An Equivalence”  
University of Melbourne Economic Theory and Experiments Seminar (April 7, 2017); Pennsylvania State University Micro Theory Seminar (March 31, 2017); University of Cologne Research Seminar of the DFG-Research Unit Design and Behavior (May 31, 2016); University of Texas at Austin Economic Theory Workshop (April 29, 2016); Nuffield College Economic Theory Lunchtime Workshop (January 19, 2016); Harvard/MIT Economic Theory Workshop (December 10, 2015); Brown University Economic Theory Seminar (November 16, 2015); Helsinki Center of Economic Research [HECER] Department Seminar (October 9, 2015); World Congress of the Econometric Society (August 21, 2015); Invited Talk, Meeting of COST Action IC1205 on Computational Social Choice (April 14, 2015); Becker Friedman Institute Celebration of the Life and Work of Gary S.

Becker (October 30, 2014); 12th Meeting of the Society for Social Choice and Welfare (June 18, 2014); 15th ACM Conference on Electronic Commerce [EC'14] (June 12, 2014); University of Chicago Special Workshop (January 24, 2014); “Frontiers of Market Design” session, AEA Meetings (January 5, 2014); Stanford University Game Theory and Computation Seminar (October 24, 2013).

“Titling in Informal Settlements”

“Market Design and Development Economics” session, AEA Meetings (January 6, 2017).

“‘Troll’ Check: A Proposal for Administrative Review of Patent Litigation”

“Market Design: Theory and Practice” session, AEA Meetings (January 6, 2017).

“Crowdsourcing City Government: Using Tournaments to Improve Inspection Accuracy”

“Predictive Cities” session, AEA Meetings (January 5, 2016).

“Full Substitutability”

“Advances in Matching Theory” session, AEA Meetings (January 4, 2016); NBER Market Design Working Group Meeting (October 23, 2015); 16th ACM Conference on Electronic Commerce [EC'15] (June 16, 2015); 3rd International Workshop on Matching Under Preferences [MATCH-UP] (April 16, 2015).

“The Coase Theorem and Voluntary Transaction Costs”

Amsterdam Center for Law & Economics Seminar (October 20, 2014); Centre de Recherches en Economie et Droit Seminar (October 16, 2014).

“Stability and Competitive Equilibrium in Trading Networks”

University of Pennsylvania Computer Science Theory Seminar (April 25, 2014); Stanford Graduate School of Business Economics Seminar (October 19, 2011); University of Wisconsin–Madison Economic Theory Workshop (September 30, 2011); Milton Friedman Institute “Matching and Price Theory” conference (May 6, 2011); “Frontiers of Matching Theory” session, AEA Meetings (January 7, 2011).

“Matching Markets with Taxation of Transfers”

Sciences Po “Taxation and Matching” workshop (March 21, 2014).

“The Demise of Walk Zones in Boston: Priorities vs. Precedence in School Choice”

Cornell University Joint Microeconomic Theory and Computer Science Seminar (April 21, 2014); University of Rochester Economic Theory Seminar (March 5, 2013); Harvard/MIT Economic Theory Workshop (February 13, 2013); Yale University Microeconomic Theory Workshop (November 6, 2013); Microsoft Research New England Game Theory & Computation Seminar (October 30, 2013).

“Designing for Diversity in Matching”

14th ACM Conference on Electronic Commerce [EC'13] (June 20, 2013); University of Maryland IO/Theory Seminar (May 7, 2013); Second Cambridge Area Economics and Computation Day [CAEC'13] (April 26, 2013); Washington University in St. Louis Economic Theory Workshop (April 16, 2013); NYU Microeconomic Theory Workshop (March 27, 2013); University of Michigan Economic Theory Seminar (March 15, 2013); “Whither Affirmative Action?” session, AEA Meetings (January 5, 2013); Microsoft Research New England Research Seminar (December 18, 2012); University of Chicago Recruitment Seminar (November 15, 2012); University of Illinois at Urbana-Champaign Microeconomics Seminar (November 7, 2012); Boston College Microeconomics Seminar (October 31, 2012); NBER Market Design Working Group Meeting (October 20, 2012); Federal Reserve Bank of Chicago Economics Research Seminar (August 14, 2012); Fourth World Congress

of the Game Theory Society [GAMES2012] (July 24, 2012); Econometric Society North American Summer Meetings (June 30, 2012); University of Haifa Economics Workshop (June 18, 2012); St. Andrews School of Economics & Finance Candlemas Seminar (April 26, 2012); University of Chicago Workshop in Economic Theory (April 10, 2012); Measuring and Interpreting Inequality Working Group Inaugural Meeting (February 18, 2012).

“A Theory of Empty Voting and Hidden Ownership”

Harvard Law, Economics, and Organizations Workshop (November 26, 2012); University of Chicago Workshop in Applications of Economics (May 21, 2012).

“Multilateral Matching”

“Price Theory and Market Design” session, AEA Meetings (January 7, 2012); Columbia Microeconomic Theory Colloquium (October 31, 2011); NBER Market Design Working Group Meeting (October 28, 2011); Maastricht Workshop on Recent Developments in Market Design (September 14, 2011); 12th ACM Conference on Electronic Commerce [EC’11] (June 9, 2011); Harvard SEAS Economics and Computer Science Research Seminar (April 14, 2011); MIT Economic Theory Research Workshop (March 1, 2011); Harvard Workshop on Research in Behavior in Games and Markets (December 1, 2010); Guest Lecture, Harvard Economics 2056a: Market Design (November 19, 2010).

“Concordance among Holdouts”

“New Challenges for Market Design” session, AEA Meetings (January 6, 2012); 12th ACM Conference on Electronic Commerce [EC’11] (June 8, 2011); Harvard Law, Economics, and Organizations Workshop (November 15, 2010); Yahoo! Key Scientific Challenges Summit (September 9, 2010); Economic Analysis Group, Antitrust Division, US Department of Justice (August 12, 2010); Harvard Business School Market Design Workshop (May 14, 2010); Harvard Workshop on Research in Behavior in Games and Markets (April 21, 2010); Harvard Graduate Student Political Economy Workshop (November 6, 2009); Harvard Law & Economics Seminar (November 5, 2009).

“Matching in Networks with Bilateral Contracts”

11th ACM Conference on Electronic Commerce [EC’10] (June 9, 2010); Northwestern EECS Economics Group Theory Seminar (April 5, 2010); Harvard Business School Negotiation, Organizations, & Markets Group Research Seminar (February 22, 2010); Stanford Market Design Workshop (January 8, 2010); Harvard SEAS Economics and Computer Science Research Seminar (November 19, 2009).

“Contract Design and Stability in Matching Markets”

“Pricing and Contracts” session, AEA Meetings (January 9, 2011); University of Chicago Informal Labor Economics Seminar (April 7, 2010); Guest Lecture, Harvard Economics 2056a: Market Design (November 20, 2009); Harvard Workshop on Research in Behavior in Games and Markets (November 18, 2009).

“Sticky Content and the Structure of the Web”

Workshop on Economics of Networks, Systems, and Computation [NetEcon] (July 7, 2009); Harvard SEAS Economics and Computer Science Research Seminar (April 30, 2009).

“Dynamic Position Auctions with Consumer Search”

5th Conference on Algorithmic Aspects in Information and Management [AAIM] (June 16, 2009); Harvard SEAS Economics and Computer Science Research Seminar (November 4, 2008).

“Clubs, Beliefs, and Entrapment”

AMS Session on “Behavioral Sciences,” Joint Mathematics Meetings (January 7, 2009).

“Configurations of Extremal Even Unimodular Lattices”

MathFest Student Paper Session (August 1, 2008); Brown Symposium for Undergraduates in the Mathematical Sciences (March 8, 2008); Harvard Undergraduate Research Symposium (November 11, 2006); Harvard College Program for Research in Science and Engineering [PRISE] (August 23, 2006).

“On Universality Properties of Positive-Definite Integral Quadratic Forms”

Harvard Math 99r: Tutorial on Binary Quadratic Forms (January 6, 2006); Intel International Science and Engineering Fair (May 12, 2005); Research Science Institute (July 29, 2004).

### **Plenary Talks and Invited Addresses**

“Platform Competition in a Web3 Future,” Keynote Lecture, Implementing Antitrust 3.0 Conference, Stanford University (December 7, 2022).

“How Will Web3 Change Business and Society?” (with Hiroto Furuhashi), Rakuten Optimism Conference (September 28, 2022).

“Redistribution and Market Design,” Paul Kleindorfer Lecture, Conference on Economic Design (June 10, 2022).

“Fighting Inequality with Markets,” Public Lecture, University of Melbourne (July 25, 2019); Pathbreakers Session, Harvard Business School Reunions (June 7, 2019).

“Good Markets (Really Do) Make Good Neighbors,” First Workshop on Mechanism Design for Social Good [MD4SG] (June 26, 2017).

“Decisionmaking and Behavioral Economics: From Theory and Experiments to Policy,” Kavli Frontiers of Science U.S. Symposium (November 5, 2015).

“Measuring PRISE’s Success,” Harvard College Program for Research in Science and Engineering [PRISE] Anniversary Celebration (June 19, 2015).

“The Future of Economic Design,” University of Chicago Symposium on Technology and Society (May 2, 2015).

“Generalized Matching Market Design,” Fields Institute Conference on Optimization, Transportation and Equilibrium in Economics (September 15, 2014).

“Theory, Practice, and Engineering in (Generalized) Matching Market Design,” Harvard Center for Research on Computation and Society [CRCS] Lunch Seminar (November 20, 2013).

“*N* Things I Wish I Understood About (Differential) Privacy,” Simons Foundation Workshop on Applications of Differential Privacy to Economics and the Social Sciences (March 7, 2013).

“Crisp Printing and Small Type,” ScienceMONTGOMERY Award Ceremony (March 20, 2011).

“Frontiers of Matching Theory,” Vassar College Mathematics Colloquium (October 12, 2010).

“Configurations of Extremal Type II Lattices and Codes,” Morgan Prize Lecture, AMS-MAA-SIAM Special Session on “Research in Mathematics by Undergraduates,” Joint Mathematics Meetings (January 15, 2010).

### **Expository Lectures (selected)**

“Intro to Intellectual Property Strategy for Web3,” Crypto Startup School, a16z crypto (April 5, 2023).

“Auction Theory,” Crypto Startup School, a16z crypto (April 4, 2023).

“Web3 Business Strategy,” Crypto Startup School, a16z crypto (April 4, 2023).

“Theory, Practice, and Engineering in Market Design,” Distinguished Lecture, Harvard College Program for Research in Science and Engineering [PRISE] (July 7, 2020; July 10, 2018; June 27, 2017; June 28, 2016; July 22, 2014; July 11, 2013; July 5, 2012).

“Theory, Practice, and Engineering in Market Design,” Becker Friedman Institute Summer Research Experience for Undergraduates, University of Chicago (June 29, 2012).

“How Much Do You Bid?,” Guest Lecture, The Math Circle (May 3, 2009).

“Matchmaker, Matchmaker, Clear Out My House (an introduction to the theory of matching),” Harvard Mathematics Table (November 21, 2008).

“ $C = 15$  (new and old results of quadratic form representation theory),” Harvard Mathematics Table (October 20, 2007).

### **Discussant Service**

“Fair Allocation of Vaccines, Ventilators and Antiviral Treatments: Leaving No Ethical Value Behind in Health Care Rationing” by Parag Pathak, Tayfun Sönmez, M. Utku Ünver, and M. Bumin Yenmez, Virtual Market Design Seminar (October 12, 2020).

“Platform Design when Sellers Use Pricing Algorithms” by Justin Johnson, Andrew Rhodes, and Matthijs Wildenbeest, “Pricing Algorithms, Competition, and Collusion” session, AEA Meetings (January 6, 2020).

“Information Cascades and Threshold Implementation” by Lin William Cong and Yizhou Xiao, “Applications of Auctions and Negotiations” session, AEA Meetings (January 6, 2019).

“Litigating Innovation: Evidence from Securities Class Action Lawsuits” by Elisabeth Kempf and Oliver Spalt, “Corporate Governance: Creditor and Shareholder Monitoring” session, AEA Meetings (January 6, 2019).

“Designing Advance Market Commitments for New Vaccines” by Michael Kremer, Jonathan Levin, and Christopher M. Snyder, Human Capital and Economic Opportunity [HCEO] Global Working Group “Development Economics & Market Design” conference (October 28, 2018).

“Need vs. Merit: The Large Core of College Admissions Markets” by Avinatan Hassidim, Assaf Romm, and Ran I. Shorrer, “Large Matching Markets” session, AEA Meetings (January 6, 2018).

“Game Abstractions for Counterfactual Prediction in Online Markets” by J. Mark Hou, Eric Sodomka, and Nicolas E. Stier-Moses, “Frontiers of Economic Theory and Computer Science” conference, Becker Friedman Institute (August 13, 2016).

“Chinese College Admissions and School Choice Reforms: Theory and Experiments” by Yan Chen and Onur Kesten, “Market Design Experiments” session, AEA Meetings (January 3, 2014).

“Localization and Colocalization within an Urban Area” by Stephen B. Billings and Erik B. Johnson, NBER Summer Institute Workshop on Urban Economics (July 22, 2013).

“Dynamic Contracting: An Irrelevance Result” by Péter Eső and Balázs Szentes, Cowles Foundation Conference in Economic Theory (June 3, 2013).

“Optimal Auction Design and Equilibrium Selection in Sponsored Search Auctions” by Benjamin Edelman and Michael Schwarz, “Designing Online Advertising Markets” session, AEA Meetings (January 5, 2010).

## ACADEMIC ACTIVITIES

### Leadership

2020 – present Scientific Council Member, Group for Research in APplied Economics [GRAPE], Poland

2019 – present Vice-Chair, Association for Computing Machinery [ACM] Special Interest Group on Economics and Computation [SIGecom]

2019 – present Advisory Board Member, Centre for Market Design, University of Melbourne

2018 – present National Leadership Council Member, Society for Science  
Governance Committee Co-Chair (2021 – present)

2011 – present Co-Leader, Human Capital and Economic Opportunity [HCEO] “Inequality: Measurement, Interpretation, and Policy” Working Group [MIP]

### Organizational

2018 – present Co-Organizer, Program on “Mathematics and Computer Science of Market and Mechanism Design,” Mathematical Sciences Research Institute [MSRI]

2023 Co-Organizer, ACM SIGecom Winter Meeting on “Crypto & Web3”

2015 – 2022 Co-Organizer, “Conference on Big Data,” Center of Mathematical Sciences and Applications, Harvard University

2021 Senior Program Committee Member, “Conference on Web and Internet Economics [WINE]”

Program Committee Member (2013)

2021 Program Committee Member, “3rd International Conference on Blockchain Economics, Security and Protocols [Tokenomics2021]”

2021 Program Committee Member, “ACM Conference on Equity and Access in Algorithms, Mechanisms, and Optimization [EAAMO]”

- 2021 Program Committee Member, “Symposium on Foundations of Responsible Computing [FORC]”
- 2020 – 2021 Program Committee Member, “Conference on Mechanism and Institution Design [CMID]”
- 2011 – 2020 Co-Organizer, American Economic Association Meetings sessions:
  - 2020 “Matching under Inequality: Implications for Policy”
  - 2019 “Dysfunction in the Real Estate Market”
  - 2019 “New Advances in Matching with Contracts”
  - 2019 “Technological Progress and Inequality: Perspectives from Optimal Tax Theory”
  - 2018 “New Insights on Classic Questions in Matching Theory”
  - 2017 “Matching without Substitutes: Theory and Applications” (*Papers & Proceedings*)
  - 2017 “Market Design and Development Economics”
  - 2017 “Market Design: Theory and Practice”
  - 2016 “Predictive Cities” (*Papers & Proceedings*)
  - 2015 “Patent Economics”
  - 2014 “Frontiers of Market Design” (*Papers & Proceedings*)
  - 2013 “Whither Affirmative Action?”
  - 2012 “New Challenges for Market Design” (*Papers & Proceedings*)
  - 2012 “Price Theory and Market Design”
  - 2011 “Frontiers of Matching Theory”
- 2020 Program Committee Member, “North American Winter Meeting of the Econometric Society”
- 2020 Program Committee Member, “Thirty-Fifth AAAI Conference on Artificial Intelligence”
- 2016 – 2019 Co-Organizer, “Social Science Applications Forum,” Center of Mathematical Sciences and Applications, Harvard University
- 2018 – 2019 Workshops Co-Chair, “ACM Conference on Economics and Computation [EC]”
  - Senior Program Committee Member (2019 – 2020; 2017; 2014 – 2015); Program Committee Member (2023; 2021; 2012 – 2013)
- 2018 – 2019 Co-Chair, “Japanese-American-German Frontiers of Science [JAGFoS] Symposium,” Alexander von Humboldt Foundation, Japan Society for the Promotion of Science, and National Academy of Sciences
  - Planning Group Member (2017)
- 2018 Co-Organizer, HCEO MIP Meeting on “Development Economics and Market Design”
- 2017 – 2018 Program Committee Member, “Workshop on the Economics of Networks, Systems and Computation [NetEcon]”
- 2017 Co-Chair, “Fourth International Workshop on Matching Under Preferences [MATCH-UP]”
- 2013 – 2017 Co-Organizer, Chicago Summer School on Socioeconomic Inequality

- 2016 Co-Organizer, “Predictive Cities” exploratory seminar, Radcliffe Institute for Advanced Study
- 2016 Co-Organizer, HCEO MIP Meeting on “Market Design Perspectives on Inequality”
- 2015 Co-Chair, “Conference on Auctions, Market Mechanisms and Their Applications [AMMA]”
- 2015 Program Committee Member, “Workshop on Social and Information Networks”
- 2015 Program Committee Member, “International World Wide Web Conference [WWW]”
- 2014 – 2015 Co-Organizer, “CRCS Seminar,” Center for Research on Computation and Society [CRCS], Harvard University
- 2014 Co-Organizer, “Midway Market Design Workshop [MDW MDW],” Becker Friedman Institute for Research in Economics, University of Chicago
- 2014 Co-Organizer, “25th Jerusalem School in Economic Theory: Matching and Market Design”
- 2014 Program Committee Member, “12th Meeting of Society for Social Choice and Welfare”
- 2014 Program Committee Member, “Symposium on Algorithmic Game Theory [SAGT]”
- 2014 Co-Organizer, “Taxation and Matching” workshop, Department of Economics, Sciences Po
- 2011 – 2012 Organizer, “Workshop in Economic Theory,” Department of Economics, University of Chicago, Fall
- 2012 Co-Organizer, HCEO MIP Meeting on “Intergenerational Mobility”
- 2012 Lead Organizer, HCEO MIP Inaugural Meeting
- 2012 Co-Organizer, “Matching Theory: Economics meets Mathematics” conference, Becker Friedman Institute for Research in Economics and Stevanovich Center for Financial Mathematics, University of Chicago
- 2011 Organizational Chair, “Matching and Price Theory” conference, Milton Friedman Institute for Research in Economics, University of Chicago

#### **University Committee Service**

- 2019 – present Member, FAS–SEAS Committee on Applied Mathematics, Harvard University
- 2017 – present Member, University Subcommittee on the Degree of Doctor of Philosophy in Business Economics, Harvard University
- 2017 – present Member, Departmental Committee on the Undergraduate Concentration in Applied Mathematics – Economics Track, Department of Economics, Harvard University
- 2019 – 2022 Executive Committee Member, University Committee on Registration and Course Allocation, Harvard University
- Member (2018 – 2019)

#### **Editorial Service**

- 2023 – present Editor, *Review of Economics and Statistics*
- 2022 – present Board of Editors Member, *Journal of Economic Literature*
- 2021 – 2022 Associate Editor, *Journal of Economic Theory*

2021 – 2022 Associate Editor, *ACM Transactions on Economics and Computation*  
 2018 – 2022 Associate Editor, *Management Science*  
 2018 – 2022 Associate Editor, *Journal of Mechanism and Institution Design*  
 2021 – 2022 Guest Co-Editor, Issue on the Economics of Vaccines and Pandemic Response, *Oxford Review of Economic Policy*  
 2018 – 2019 Guest Co-Editor, Issue on EC'17, *ACM Transactions on Economics and Computation*  
 2017 Guest Co-Editor, Issue on Market Design, *Oxford Review of Economic Policy*

#### Other Professional Service

2019 – present Senior Common Room Member, Lowell House, Harvard University  
 2019 – 2022 Selection Committee Member, Jon C. Graff Prize for Excellence in Science Communication, Society for Science  
 2013 – 2021 Mathematics Grand Awards Co-Chair, International Science and Engineering Fair [ISEF], Society for Science  
 2021 – 2022 Selection Committee Member, Nakahara Prize, Japanese Economic Association  
 2013 – 2017 Selection Committee Member, Joseph Lieberman Award for Significant Contribution to Science and Technology, Center for Excellence in Education  
 2011 Head Tutor, Program for Research in Markets and Organizations [PRIMO], Harvard Business School  
 2009 – 2011 Non-Resident Tutor, Kirkland House, Harvard University  
 2005 – 2011 Paper Reviewer, Research Science Institute, MIT  
 2008 Program Assistant, Program for Research in Science and Engineering [PRISE], Harvard College

#### ACADEMIC ADVISING

##### Graduate

Name	Year	Institution	Field(s)	Initial Placement
Hanzhe Zhang	2015	Chicago	Applied Theory, Market Design	Michigan State University
Jörn Boehnke	2015	Chicago	Industrial Organization	Harvard CMSA (postdoc)
Kentaro Tomoeda	2016	Harvard	Theory, Market Design	University of Technology Sydney
Benjamin Roth	2017	MIT	Development, Market Design	Harvard Business School, EM Unit
Ging Cee Ng	2018	Chicago	Applied Micro, Public Finance	Analysis Group

Neil Thakral <sup>M</sup>	2018	Harvard	Applied Micro, Behavioral	Brown University
Carmen Wang	2018	Harvard	Market Design, Experimental	Uber
Abraham Holland	2019	Harvard	Development, Market Design	Institute for Defense Analyses
Yosub Jung	2019	Harvard	Finance, Entrepreneurship	Analysis Group
Hongyao Ma <sup>SIGecom</sup>	2019	Harvard	Market Design	Columbia Business School
Ravi Jagadeesan <sup>M</sup>	2020	Harvard	Market Design, Theory, Macro	Stanford (postdoc)
Zhe Feng	2021	Harvard	Market Design	Google Research

<sup>M</sup> = awarded the Martin Award for Excellence in Doctoral Research in Business Economics

<sup>SIGecom</sup> = awarded the ACM SIGecom Doctoral Dissertation Award

### Undergraduate

Name	Degree	Year	Graduate Institution (if any)
Janet Lu <sup>NSF,PBK</sup>	AB, <i>summa</i>	2014	Columbia (PhD)
Zoë Hitzig <sup>H</sup>	AB, <i>magna</i>	2016	Cambridge (MPhil); Harvard (PhD)
David Freed <sup>H,Ha,PBK</sup>	AB, <i>magna</i> with highest honors; SM	2016	
Evan Zimmerman	BA + honors	2016	Berkeley (Law)
Nathaniel Ver Steeg <sup>H,PBK</sup>	AB, <i>summa</i>	2017	Cambridge (MPhil)
Ravi Jagadeesan <sup>W,H,Mo,NSF,PBK</sup>	AB, <i>summa</i> ; AM	2018	Harvard (PhD)
Jiafeng Chen <sup>H,PBK</sup>	AB, <i>summa</i> ; AM	2019	Harvard (PhD)
Shira Li <sup>H</sup>	AB, <i>magna</i> with highest honors	2019	Harvard (PhD)
Hannah Ellery <sup>H</sup>	AB, <i>magna</i> with highest honors	2021	Harvard (PhD)

<sup>W</sup> = awarded the Jacob Wendell Scholarship Prize

<sup>H</sup> = awarded the Thomas Temple Hoopes Prize

<sup>Ha</sup> = awarded the Seymour E. and Ruth B. Harris Prize

<sup>NSF</sup> = awarded an NSF Graduate Research Fellowship

Mo = awarded the AMS-MAA-SIAM Frank and Brennie Morgan Prize  
PBK = Phi Beta Kappa

### Economic Design Fellows

Name	Home Institution	Year	Field(s)	Next Port of Call
Max Cytrynbaum	Chicago	2015	Market Design	MIT (PhD)
Nick Jaeger	Woodside Priory	2015	Applied Micro	Harvard (AB)
Ravi Jagadeesan <sup>W,H,Mo,PBK</sup>	Harvard	2016 – 2018	Theory, Math, Market Design	Harvard (PhD)
Robbie Minton	Chicago	2016	Price Theory, Applied Micro	Harvard (PhD)
Ross Rheingans-Yoo	Harvard	2016	Theory, Math, Market Design	Jane Street
Joseph Shayani <sup>PBK</sup>	Stanford	2016	Theory, Computer Science, Market Design	MIT (PhD)
Daniel Chavez	Chicago	2017	Theory, Applied Micro	Analysis Group
Jiafeng Chen <sup>PRISE,PBK</sup>	Harvard	2017	Market Design, Theory, Applied Micro	Harvard (PhD)
George Hou <sup>PRIMO</sup>	Harvard	2017	Applied Micro	Silver Lake
Alan Lam	Harvard	2017	Entrepreneurship	PJT
Shira Li <sup>PRIMO</sup>	Harvard	2017	Theory, Math, Market Design, Computer Science	Goldman
Duncan Rheingans-Yoo <sup>PRISE</sup>	Harvard	2017	Computer Science, Market Design	Jane Street
Winston Shum	Lawrenceville	2017	Entrepreneurship, Sustainability	Stanford (BA)
Charlie Ughetta	Princeton	2017	Entrepreneurship, Finance	Jeffries
Franklyn Wang <sup>RSI</sup>	Thomas Jefferson	2017 – 2018	Theory, Math, Market Design, Computer Science	Harvard (AB)
Claire Shi <sup>PRIMO,PBK</sup>	Harvard	2018	Behavioral, Market Design	Harvard (PhD)

Michael Zarian <sup>PRIMO</sup>	Harvard	2018	Entrepreneurship	
Gerald Xu	Deerfield	2018	Theory, Math, Market Design	Harvard (AB)
Matthew Shum	Lakeside School	2018	Theory, Math, Market Design	Harvard (AB)
Aditya Dhar <sup>PRIMO, PRISE</sup>	Harvard	2019	Theory, Econometrics	US CEA
Jimmy Lin <sup>PRIMO</sup>	Harvard	2019	Theory, Computer Science	Quantco
Mirac Suzgun	Harvard	2019	Computer Science, Applied Macro	Stanford (PhD)
Douglas Yang	Andover	2019	Math	Harvard (AB)
Siye Zhu <sup>PRISE, PBK</sup>	Harvard	2019	Theory, Applied Micro	Two Sigma
Yunseo Choi <sup>RSI</sup>	Exeter	2020	Theory, Math	Harvard (AB)
Louis Golowich <sup>PRIMO</sup>	Harvard	2020	Theory, CS	Berkeley (PhD)
Andrew Garber <sup>PRIMO, PBK</sup>	Harvard	2021 – 2022	Theory, Math, Market Design	
Suat Evren <sup>PRIMO</sup>	MIT	2022	Theory, CS, Market Design	

<sup>W</sup> = awarded the Jacob Wendell Scholarship Prize

<sup>H</sup> = awarded the Thomas Temple Hoopes Prize

<sup>PRISE</sup> = Program for Research in Science and Engineering Fellow

<sup>PRIMO</sup> = Program for Research in Markets and Organizations Fellow

<sup>RSI</sup> = Research Science Institute Summer Scholar

<sup>Mo</sup> = awarded the AMS-MAA-SIAM Frank and Brennie Morgan Prize

<sup>PBK</sup> = Phi Beta Kappa

## ENTREPRENEURIAL ADVISING (SELECTED)

2021 – present Advisory Board Member, Thingdoms, Scotland, UK

2021 – present Advisory Board Member, Hungry Wolves NFT, Austin, TX

2021 – present Advisory Board Member, FINE Digital

2021 – present Advisory Board Member, koodos, New York, NY

2021 – present Advisory Board Member, OneChronos, New York, NY

2019 – present Advisory Board Member, Lunchclub, San Francisco, CA

2020 – 2022 Exchange Design Technical Advisory Panel Member, COVAX, Geneva, Switzerland

Scott Duke Kominers

May 5, 2023

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2018 – 2021 Economic Advisor, Novi Financial, Inc., Menlo Park, CA

## REFEREEING

**Economics:** *American Economic Journal: Economic Policy, American Economic Journal:*

*Microeconomics, American Economic Review, Cambridge University Press, Econometrica, Economic Journal, Economic Theory, Economics and Business Letters, Economics Letters, European Journal of Operational Research, European Research Council [ERC], Games and Economic Behavior, International Journal of Game Theory, International Journal of Industrial Organization, Journal of Economic Behavior and Organization, Journal of Economic Geography, Journal of Economic Literature, Journal of Economic Theory, Journal of Finance, Journal of Health Economics, Journal of Law and Economics, Journal of Law, Economics and Organization, Journal of Legal Studies, Journal of Mathematical Economics, Journal of Political Economy, Journal of the European Economic Association, Journal of Urban Economics, Management Science, Mathematical Social Sciences, Mathematics of Operations Research, National Science Foundation [NSF], Operations Research, Papers in Regional Science, Proceedings of the National Academy of Sciences, Public Choice, Quarterly Journal of Economics, RAND Journal of Economics, Review of Economic Studies, Southern Economic Journal, Swiss National Science Foundation [SNSF], Theoretical Economics, U.S.-Israel Binational Science Foundation, Yale University Press*

**Computer Science:** *AAAI Conference on Artificial Intelligence [AAAI], ACM Conference on Economics and Computation [EC], ACM Conference on Equity and Access in Algorithms, Mechanisms, and Optimization [EAMMO], Algorithms, Artificial Intelligence, Conference on Web and Internet Economics [WINE], Innovations in Theoretical Computer Science Conference [ITCS], International Workshop on Computational Social Choice [COMSOC], International World Wide Web Conference [WWW], Symposium on Discrete Algorithms [SODA], Symposium on Foundations of Computer Science [FOCS], Symposium on Foundations of Responsible Computing [FORC], Workshop on Auctions, Market Mechanisms and Their Applications [AMMA], Workshop on the Economics of Networks, Systems, and Computation [NetEcon], Workshop on Social and Information Networks*

**Mathematics:** *American Invitational Math Exam [AIME], American Mathematics Competition [AMC], Applicable Analysis and Discrete Mathematics, Current Science, Discrete Applied Mathematics, Journal of Integer Sequences, Journal of Number Theory, Journal of Theoretical Biology*

**Sociology:** *American Sociological Review*

### 3 Documents Considered

#### Documents Provided By Counsel:

(001) 2022-02-03 Complaint against StockX  
 (039) 2022-05-25 First Amended Complaint  
 NIKE0000055  
 NIKE0000130  
 NIKE0000244  
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 NIKE0000391  
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 NIKE0064423  
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 NIKE0064430  
 STX0015563  
 STX0061875  
 STX0102499  
 STX0806025  
 STX0806026

#### Further References:

Allayannis, Yiorgos and Aaron Fernstrom. *An Introduction to Blockchain*. University of Virginia Darden School of Business Note 7356. URL: <https://hbsp.harvard.edu/product/UV7356-PDF-ENG>.  
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- *Why can’t I see my transaction on the blockchain?* URL: <https://help.coinbase.com/en/coinbase/trading-and-funding/buying-selling-or-converting-crypto/why-cant-i-see-my-transaction-on-the-blockchain>.
- Cointelegraph. “Polygon Blockchain explained: A beginner’s guide to Matic”. In: *Cointelegraph* (July 2022). URL: <https://cointelegraph.com/learn/polygon-blockchain-explained-a-beginners-guide-to-matic>.
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- Cryptoxican. *To be eligible*. Dec. 2022. URL: [https://twitter.com/cryptoxican\\_/status/1603662572108283909](https://twitter.com/cryptoxican_/status/1603662572108283909).
- Doodles. *Doodles - Collection*. URL: <https://opensea.io/collection/doodles-official>.
- *Doodles 2 Wearables: Gaia - NFT Marketplace on Flow*. URL: <https://ongaia.com/doodles2wearables>.
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- Etherscan. URL: <https://etherscan.io/>.
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